THE SPAS OF EUROPE.

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PREFACE.

MINERAL waters have a special claim upon the attention of the medical Profession, not only on account of their remarkable physiological and therapeutical properties, but also because they are the only medicines offered to us by Nature in a state fit for immediate use. Almost all other of our most powerful and effective remedies, whether taken from the vegetable or the mineral kingdom, require varied and careful preparation before they can be introduced into the system; and even then the doses and combinations in which they are to be given, form the subject of deep and anxious consideration, and which, in spite of the progress actually made, are by no means so settled as is desirable. In mineral waters, on the contrary, we have a great variety of gentle as well as powerful remedies ready prepared, which the experience of

thirty centuries has proved to be of a most admirable composition so as to suit the most various diseases and constitutions; and which often prove far superior to the artificial compounds prepared from our prescriptions in the pharmacies. I may here appropriately quote the words of one of the greatest Physicians of the last century: I allude to Boerhave who, when speaking of the remedial powers of iron, says:— "In ferro est aliquod divinum, sed numquam praeparata ejus artificialia id operantur quod acidulae martiales".

Although the subject of mineral waters is therefore one of vast importance, it has of late been very much neglected by the medical Profession of this country. There is not a treatise in the English language which can be said to represent at all the present state of this department of science; and in vain do we look in the Transactions of learned Societies, and in the many medical periodicals of which this country justly boasts, for indications that mineral waters are the subject of study and consideration. This is probably due to the circumstance, that this country is not so rich in remarkable Spas as the Continent, and that therefore the opportunities for observing their effects are not so plentiful here as elsewhere. The use of mineral waters has,

however, in consequence of the great facilities now afforded for travelling, and also through the high degree of perfection attained in the manufacture of artificial mineral waters, become so general, that an intimate knowledge of the subject is of the greatest importance to the medical Practitioner. The numerous questions connected with the nature and action of mineral waters, have been the subject of long and earnest study on my part; and having been often asked for information respecting them by my professional brethren and others, I now venture to submit to their notice this treatise, which, it is hoped, may fill up a hiatus that has hitherto existed in British medical literature.

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ERRATA.

Before perusing the book, the reader is requested to correct the following errata, which, from the book having been printed at a great distance, have unavoidably crept into the text:—

Title last line *for* righl *read* right

Page	VI	line 7	*for* Boerhave *read* Boerhaave
-	IX	- 6	fr. bot. *for* ascendings *read* ascending
-	XII	- 1	*for* Carhonic *read* Carbonic
-	XVIII	- 11	*for* Leanington *read* Leamington
-	8	- 9	fr. bot. *for* pla-ced *read* placed
-	10	- 1	fr. bot. *for* obser-ved *read* observed
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-	46	- 5	*for* la-yers *read* layers
-	46	note line 2	*for* were *read* where
-	49	line 10	*for* uncheck-ed *read* unchecked
-	51	- 17	*for* Lucrece *read* Lucretius
-	51	- 17	*for* Ovidius *read* Ovid
-	56	- 5	fr. bot. *for* typographical *read* topographical
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-	68	- 8	fr. bot. *for* for *read* of
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-	77	- 10	*for* Appennines *read* Apennines
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-	93	- 13	fr. bot. *for* than *read* that
-	94	- 12	fr. bot. *for* mortale *read* Mortale
-	95	- 7	fr. bot. *for* of iron, of magnesia *read* of iron and magnesia
-	104	- 3	*for* below *read* under
-	104	- 7	*for* Abscheron *read* Apsheron
-	107	- 7	fr. bot. *behind* crimson *add* colour
-	108	- 6	*for* nummer *read* number
-	110	- 15	fr. bot. *behind* 15 *add* more

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- 124	- 5	fr. bot. *for* beaftea *read* beeftea
- 125	- 19	*for* fossile *read* fossil
- 140	- 3	*for* twelvth *read* twelfth
- 140	- 4	fr. bot. *for* mfro *read* from
- 143	- 8	fr. bot. *for* with *read* in
- 145	- 7	*for* twelvth *read* twelfth
- 165	- 13	*after* having been *supply* in
- 176	- 3	fr. bot. *for* twelvth *read* twelfth
- 178	- 19	- - - -
- 211	- 2	fr. bot. *for* hte *read* the
- 214	- 3	fr. bot. *for* epiderms *read* epidermis
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- 318	- 18	*for* energetical *read* energetic
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- 483	- 30	(2 col.) *for* Liebcrmeister *read* Liebermeister
- 483	- 2	fr. bot. *for* Lucrece *read* Lucretius
- 484	- 18	fr. bot. (1 col.) *for* Ovidius *read* Ovid
- 493	- 4	(2 col.) *for* Starley-Bunn *read* Stenhouse Burn

CHAPTER I.

THE ORIGIN OF SPRINGS.

THERE are few phenomena in natural history so full of wonder to the uneducated, and so replete with interest for the philosopher, as those connected with the origin of springs. Sulphurous waters which rise from the bottom of the sea; hot springs breaking through a cover of ice and snow; acidulated alkalines and chalybeates which ascend with gurgling and hissing noises; intermittent springs which disappear at certain hours of the day to become again visible at others; incrustating calcareous waters, which cover everything they meet with a strong deposit of lime, so that plants and other objects, over which they have passed, seem to have become suddenly petrified:—these and many other phenomena of a similar character could not fail to occupy the attention of natural philosophers from an early period; and on searching the works of ancient as well as modern writers, we find indeed a great variety of more or less ingenious opinions as to the causes of such extraordinary appearances. It is not my intention, in the present work, to enter into a lengthened discussion of the numerous theories, which have up to the present time been propounded on this subject; I will only mention a ~~few of the~~ most important amongst them.

The theory which prevailed throughout antiquity and the middle ages, originated with Aristotle. It was to the effect that large caverns containing air existed in the interior of the earth; and that at the roofs of these caverns the air was, by the cold, condensed to water, which broke forth at the surface, wherever it could find an outlet. We now know, that air can no more be changed into water, than lead into gold; but Aristotle's opinion reigned supreme for many centuries, little attention being paid to another remark made by him, that certain springs had their origin in atmospheric moisture which was attracted by mountains, accumulated in grottoes, and afterwards reappeared on the surface as springs. Vitruvius, however, was of opinion, that the springs were owing to rain and snow, which penetrated the pores of the earth and formed subterranean reservoirs; while Seneca remarked, that the experience made in his vineyards induced him to believe, that water could not percolate through the soil deeper than ten feet.

A new theory was proposed by the French philosopher Descartes, who, although he effectually destroyed many errors and prejudices which were held sacred by the Scholastics of the middle ages, was not equally fortunate in discovering the true origin of springs. He supposed the interior of the earth to contain a peculiar distillatory apparatus, which consisted of large caverns to which water from the sea was carried by means of canals; and where it was, by the action of the central fire, changed to vapour, the saline matter being at the

same time precipitated. At the vaults of the caverns, where the temperature was low, the vapours were condensed to water, which was forced upwards, and escaped through such fissures and crevices as it encountered. It evidently did not occur to Descartes that, even if these hypothetical caverns had ever existed, they must have long ago been filled up by the amount of salines deposited in them during the lapse of centuries.

Kirschner, a German, and R. Plot, an English philosopher, attributed the origin of springs to capillary power, by which water from the bottom of the sea rose through the pores of the earth to the surface. This opinion was also held by Varenius and many others; but it is evident, that capillary power is insufficient to raise water to the height, to which many springs rise. Moreover, if this theory were correct, every spring would contain a considerable amount of salines; and countries which are situated below the level of the sea, such as Holland and part of the territory traversed by the river Volga, would necessarily be always inundated.

The correct explanation of the origin of springs was almost simultaneously given by a French and an English philosopher, Edme Mariotte, and Edmond Halley, who investigated the subject independently of one another. Questions of this kind can only be settled by direct experiment, and this was the course Mariotte was the first to pursue. He endeavoured to determine, whether the quantity of water precipitated from the atmosphere, was not sufficient to account for the numer-

ous springs and rivers which exist on the earth. He first calculated the mean quantity of rain which fell in the neighbourhood of Paris, and compared it with the water furnished by the river Seine. The result was, that the former was six times larger than the latter, so that there appeared to be a more than sufficient supply for feeding the river. More recent researches undertaken in Paris by M. Arago have shown, that only one third of the meteoric water (rain, snow, dew &c.) is carried off by the Seine, the remainder being absorbed by the bed of the river, or returned as vapour into the air. Mariotte concluded from his experiments, that the springs were due to rain, dew, snow and other moisture which fell upon the hills and mountains, and filtered through the soil, till it met with impervious layers in the interior, through which it was unable to pass; it therefore continued its course along them in an oblique direction, until having descended a considerable distance from the top, it found egress and was discharged in springs.

Halley, in making astronomical observations upon the summits of the hills of St. Helena, 800 yards above the level of the sea, found, that the quantity of vapour which fell there, even when the sky was serene, was so considerable, that it impeded his observations by covering his glasses with moisture; and the paper on which he made notes, soon became so damp, that it would not bear ink. He was thereby induced to make experiments, for the purpose of ascertaining the amount of vapour exhaled by the Sea, in order to determine whether that was sufficient to supply the contents of

springs and rivers. He filled a pan, four inches deep and eight inches in diameter, with water salted to the same degree as sea-water; in this he placed a thermometer and heated the water to the same degree as is possessed by the sea in summer. He then weighed the vessel, and found, at the end of an hour, that 233 grains of water had evaporated, although the water was scarcely warm; in twenty-four hours this loss would amount to twelve ounces. He then assumed the Mediterranean to be forty degrees long and four broad, so that its whole surface would be 160 square degrees; and calculated that, according to the experiment just mentioned, that sea would lose at least 5280 million tons of water during one summer's day. In this calculation no regard was had to other causes of evaporation, which cannot be reduced to rule, such as wind, and the agitation of the surface of the sea, which considerably promote evaporation. This quantity of water was then compared with that which is daily discharged into the Mediterranean by rivers. In order to give the opponents of his theory every chance, Halley assumed these rivers to be greater than in all probability they are; and then compared the quantity of water voided by the Thames with that of those rivers, the water of which he wished to compute. The Mediterranean receives nine large rivers, viz. the Ebro, the Rhone, the Tiber, the Po, the Danube, the Dniester, the Borysthenes, the Tanais and the Nile, the others being of no great note, and the quantity of water discharged by them inconsiderable. Each of these nine rivers he supposed to bring

down ten times as much water as the Thames, thus making an allowance for such small rivulets as fall into the same sea and cannot otherwise be comprehended in the calculation. He estimated the daily discharge of water by the Thames at Kingston bridge to be 20,300,000 tons; if, therefore, each of the nine rivers mentioned above, yielded ten times as much water as the Thames, each of them would yield 203 million tons per diem, and the whole nine, 1827 million tons; which is but little more than one third of what is proved to evaporate from the Mediterranean. In evaporation from the ocean we have, therefore, a more than sufficient source for a constant supply of springs.

If water passes from the liquid into the gaseous state, it expands, becomes specifically lighter than air, and rises so long as it continues to be thus distended. But in proportion as the air becomes not only colder, but also more rarefied, the vapours cease to ascend, and either form clouds, or fall as rain, hail, snow or dew. Winds then carry them to the land, to which they are also attracted by the free electricity of the earth, the quantity of which is largest on the summits of mountains, where vapours, therefore, tend to accumulate, and where at a certain degree of temperature they are precipitated. Where the soil is compact, the water thus formed immediately flows off again; but where it is permeable, the water percolates through it, and forms springs further down. By far the greatest part of the vapours which rise from the ocean, however, falls back into it as rain or dew, before it reaches the land; and

another part is precipitated on the lowlands, where it furthers vegetation. From the land the moisture is again drawn off in vapour, by the action of the sun, and is carried either into the sea, as rain or dew; or else to the mountains, where it serves to form springs. After several vicissitudes of rising and falling, each particle of water is, therefore, returned to the sea from whence it came.

The objections which have been made to this theory, that springs are formed by meteoric water, are quite untenable. Thus it was said, that some springs issued at the summits of mountains, and that, therefore, they could not be supplied by rain or dew, there being no territory above them. The following springs were said to be of this kind: — the Hexenbrunnen, situated at the top of the Brocken, in the Hartz-Mountains, which is 3500 feet above the level of the sea, and furnishes 525, 600 cubic feet of water annually; a spring at the top of Montmartre, near Paris; one at the top of Mont Ventoux in the Pyrenees &c. At first sight this objection would seem important; but, although ordinary descending springs can certainly not exist at the summits of mountains, those just mentioned might be ascending springs, which are raised by hydrostatic pressure. But it is not necessary to resort to such suppositions, as the premises, upon which this objection is based, are incorrect. Recent investigations have shown, that the spring on Mont Ventoux is 600 feet below, and not on, the summit of the mountain; that on Montmartre is 48 feet, and the Hexenbrunnen 18 feet, below the

summit &c. The last named spring is overhung by a rock 1000 feet in diameter, which is continually surrounded by clouds; moreover snow falls in considerable masses, and the annual quantity of rain amounts to 24 inches, which latter alone would furnish three times the amount of water annually discharged by that spring.

Another objection to Mariotte's theory was, that meteoric water could not penetrate to great depths, as mica, slate, and granite, were believed to be insuperable barriers to its progress. Seneca had already expressed his opinion to this effect; and at a later period it was especially an experiment made by Messrs Perrault and Delahire (in 1690) which seemed to corroborate this view. A vessel of clay was buried, at first eight, and afterwards sixteen, feet below the surface; it was made to communicate with a cellar by means of a leaden pipe, through which any water which might arrive in the vessel, would run into the cellar. But no water was ever discharged by the pipe; and from this it was concluded, that rain did not penetrate further than a few feet belowground. The vessel was evidently placed below an impervious layer of soil; and different results would have been obtained, if the experiment had been made with penetrable strata.

There are, however, many facts to prove, that meteoric water does indeed penetrate to great depths. Thus, for instance, in mines, which are at a considerable depth beneath the surface, the walls of the different galleries and levels are continually moistened with wa-

ter, which finds its way down through the pores of the earth, especially after heavy rains, and which it is necessary to remove by pumping. The greater the obstacles presented by water in mining operations, the greater is the penetrability of the rocks. Quite recently the cutting of the tunnel through Mont Cenis afforded a striking example of this, as it was found necessary to form a canal in the centre of the way in the interior of the mountain, to carry off the waters, which continually filtered through the rock. Such facts, which were ascertained in mining operations; geognostic investigations of the character and alternation of rock-formations; observations concerning the temperature of springs, and finally the phenomena of artesian wells, have thrown so much light upon this subject, that the theory of the origin of springs may now be considered as firmly established in science. No mineral is perfectly impervious to water, which penetrates not only through fissures and crevices, but also through the substance of the rocks themselves. Porosity is not confined to coarse-grained crystalline rocks, but also exists in such as are of a finer texture, as, for instance, basalt; and stones, which are not permeable to pure water, are decomposed by water containing carbonic acid, which latter is absorbed from the atmosphere and from decaying vegetable mould.

All springs, therefore, derive their origin from meteoric water, viz. rain, dew and snow, and also from brooks, rivers and lakes, and the melting ice of glaciers. Those directly formed by meteoric water are

the descending or mountain springs, which furnish the ordinary drinking water; and the ascending springs, amongst which are many of the most remarkable mineral waters.

The mountain springs are formed in the following manner. If water is precipitated on the surface of the mountains, it filters through the rocks more or less quickly in proportion to their permeability; and pursues its course in the interior, until it reaches an impenetrable layer, along which it runs, and either reappears in springs at a lower level, or continues its subterranean course to neighbouring rivers, lakes, or seas. The impervious layers of rocks generally form an inclined plane, so that on such mountains nearly all the springs will appear on one side, and none, or scarcely any, at the other. The number of springs which issue at the declivities, and the amount of water they furnish, indicate the degree of permeability of the rock. Many springs rise in the neighbourhood of rivers, where the soil is porous and easily penetrated by water. Mountain springs rarely dry up; but the quantity of water furnished by them varies considerably according to the amount of atmospheric moisture precipitated. Some springs only appear in rainy seasons; these merely carry off the water which falls into perpendicular fissures and ravines, which are provided with outlets at the declivity of the mountains. Springs of this kind are especially to be found at the Cape, and in the Oases of the Desert. Temporary springs may also be obser-

ved in hot seasons on mountains covered with perpetual snow.

Ascending springs rise from parts of the interior of the earth, which are deeper than their point of egress; and from whence they are raised by hydrostatic pressure. They are generally found where permeable and impervious strata of the soil alternate with one another, as for instance, at the boundaries of crystalline and sedimentary rocks. When water courses along a penetrable layer, which is enclosed by impenetrable strata, it is under considerable pressure, and as soon as it encounters a rent in the upper stratum, it rises to a height proportionate to the pressure to which it is subjected. As such rents are frequently at a considerable distance from the spot where the water originally accumulated, ascending springs have often a very lengthened and tortuous course, and issue at a point remote from their place of formation. They may break out near the summits of mountains, if these are on the same level with the spot where the water, to which they owe their origin, was precipitated; but they may also rise in plains, or even from the bottom of the sea, if they there meet with a soil sufficiently loose as to allow of their egress. Many places in the sea, where fresh water might be procured, were known to the ancients, and Pliny mentions springs of this kind near the Chelidonian Isles, at Arados, in the gulf of Persia, at Gades, in the bay of Bajae &c. A fresh water spring which rises from the sea, near Syracuse, was in ancient times constantly resorted to by the inhabitants of that city, in hot and

dry seasons. Amongst many other ascending springs I will only mention one which rises from the bottom of the Mediterranean between Castellamare and Sorrento, and which emits a strong odour of sulphuretted hydrogen; a fresh water spring, which bubbles up with great force from the bottom of a saltlake near Spezzia; the thermal springs of Carlsbad, which rise from the bed of the river Tepel; the alkaline waters of Ems, which issue from the river Lahn; springs near Guadeloupe and Cuba, and in the vast plains of the North of Russia; the Spas of Wiesbaden, Aix-la-Chapelle, Gastein, Teplitz, Leuk &c. All these springs come from a very considerable depth, where immense collections of water exist; and this accounts for the fact, that the quantity of water furnished by them is not proportionate to the variations occurring in the precipitation of meteoric water, but is, in most cases, constant, and more abundant than that discharged by the mountain springs. They have generally a high temperature, which corresponds to the depth from which the springs rise. Most of them are rich in salines, which they extract from the rocks through which they flow; and if they come in contact with streams of carbonic acid, this gas is absorbed, and acidulous springs are thereby formed.

There are many proofs for the existence of such subterranean caverns filled with water, from which the ascending springs derive their origin; such as the disappearance of large masses of meteoric water, which are precipitated at a particular spot; the sinking of bor-

ers, in boring artesian wells; the evident connexion existing between several springs situated at a great distance from each other; landslips which not unfrequently take place in localities containing a number of mineral waters, such as the Auvergne, the neighbourhood of Pyrmont, Liebenstein &c. These caverns are formed by the mechanical and chemical action of the water itself. Meteoric water, before reaching the earth, contains only a very trifling amount of salines and earthy substances, but the water yielded by springs is always more or less rich in them. In the course of centuries the water, which is continually filtering through rocks, extracts from them immense masses of solid matter; and such constituents as are insoluble in pure water, are decomposed by oxygen and carbonic acid, and thus rendered soluble. The brine spring of Artern, in Prussian Saxony, discharges every year a quantity of water, from which 125 million pounds of tablesalt are extracted; so that within a twelvemonth, an excavation of a hundred cubic feet is produced by this spring in the interior of the earth. The brines of Salzuffeln, Neusalzwerk, Rehme, and others, form similar caverns; while such springs which do not pass through large beds of salt, but through rocks more or less insoluble, excavate the earth more slowly. As a space of only a hundred feet square may contain one million cubic feet of water, it is easy to comprehend why the immense subterranean caverns, in which water accumulates, may feed the springs for a considerable

time, even if no fresh addition of meteoric water were made to them.

Artesian wells (so called from the county of Artois, where they were first bored) are artificially-produced ascending springs. They are formed by carrying borings through an impermeable layer down to penetrable strata, which again rest upon an impervious layer. Egress is thereby provided for the water contained in the permeable strata, which rushes out with considerable force as soon as the permeable layer has been reached. The most favourable spots for boring such wells, are at the boundary between stratified and non-stratified rocks. Paris, for instance, rests upon a stratum of chalk about 1500 feet in depth, covered with 150 feet of various strata of tertiary soil. Between this and the Jurassic limestone, a permeable layer of green sandstone is interposed, from which the artesian wells of Grenelle and Passy derive their water. This sandstone rises to the surface on the hills surrounding Paris, and there absorbs the meteoric water which is precipitated. The well at Passy is 1760 feet deep and daily furnishes 20,000 cubic mètres of water, at a temperature of 82°. That artesian wells are fed by collections of meteoric water, is proved by the circumstance, that the water thrown up by them frequently contains moss, leaves, stems and seeds of plants, various kind of fish, and fresh-water mussels. Air, sulphuretted hydrogen, carbonic acid, carburetted hydrogen and other gases, are also often discharged from them.

I now proceed to consider the origin of those springs

which are only indirectly formed by meteoric water. Some of these have their source in sunken rivers. When the bed of a river is very much fissured, as is especially the case in limestone formations, large quantities of water are imbibed by it. If an impervious layer succeeds the penetrable, an impediment will be offered to the descent of the water, after the fissures have been filled up; but if the fissured stratum is of considerable thickness, and not succeeded by an impervious layer, the quantity of water which sinks, will be so great that the river must at last become exhausted, and finally disappear. The water thus lost accumulates in large subterranean receptacles, and reappears in springs at such points where egress is possible. Phenomena of this kind were known to the ancients, and Pliny mentions a river which sinks into the ground in the plain of Atinum (the Rio Negro) and again rises at a distance of 20 miles. The most striking instances of this kind are, however, to be found upon the western declivity of the Teutoburger Wald, in Westphalia, where six considerable brooks and small rivers disappear; the Pader, Lippe, and others, are rivers which sink from higher regions into the numerous clefts in the chalk rocks, pursue a subterranean course, and reappear at a much lower level as springs. Again, in Carniola and Illyria almost every river has a subterranean course; the Laibach river rises twice from the limestone rock and is twice again swallowed up before it makes its final appearance.

A number of springs come from lakes in high

elevations. There are several lakes which continually receive a larger amount of meteoric water by precipitation, than they give off by evaporation, and although they have no visible discharge, they never overflow. In such lakes the bottom consists of fissured rocks, and the water escapes by subterranean channels. Thus the Daubensee, on the Gemmi, in the canton of Wallis, in Switzerland, which is 7000 feet above the level of the sea, receives not only all the snow and rain water from the surrounding mountains, but also a considerable glacier-stream. Its bed consists of fissured limestone, through which a large quantity of water sinks; and 1200 feet lower down, at the Spital Matte, more than fifty copious springs break forth, which evidently originate in the Daubensee. Another instance of this kind is the Lac glacé d'or, in the valley of Larboust, in the Pyrenees, which is at an elevation of 8166 feet, and almost always frozen; through its bed, which is extremely fissured, the water sinks, and reappears as a considerable spring at Beque, 30 miles above Bagnères de Luchon *.

Other springs are supplied from glaciers, the surface of which melts during summer. If the rock upon which the glacier rests, is permeable to water, this sinks through the fissures, and after a longer or shorter subterranean course, rises at points below the level of the glacier in the form of springs. The numerous and copious springs which are found in the valleys below

* Charpentier, Essai sur les glaciers. Lausanne 1841 p. 95.

glaciers, are generally derived from this source. If they originate solely in the melting ice, they flow only so long as the warm weather continues, and dry up in winter; but if they are also fed by other sources in the interior, they flow all the year round, although less abundantly in winter.

A few springs are also due to condensation of steam, which rises from volcanic soil. In the islands of Ischia, Lipari and Pantellaria, there are grottoes communicating with the interior of the earth, and filled with steam; this is condensed at the roof of the grottoes, and supplies springs which flow permanently, and the water of which is very pure, as it cannot dissolve much solid matter in its short course to the surface.

Certain springs show a remarkable intermittence: they subside and reappear at regular or irregular intervals. In some instances this is due to the springs being dependent upon the tides; and the intervals are, in this case, very regular. Such are the thermal waters of Skogafiordar in Iceland, those of Giore, in the Vendée, the springs near Cadiz and many other places on the coast of Spain; the bath of Diana at Eleusis, and numerous springs in Greece; the artesian wells of Fulham, Abbeville, Dieppe &c. These springs and wells are either close to the sea or at a short distance from it; there is a spring at Lille which is forty miles from the sea-shore, and the oscillations of which correspond exactly to the tides, but take place eight hours after them. Phenomena of this kind are generally due to the springs having several outlets, some of which com-

municate with the sea; during high tide the discharge is prevented or at least considerably diminished, whereupon the level of the springs rises accordingly; while at low tide much water may escape, and the springs therefore become empty. It was formerly believed that such springs as were dependent upon the tides, had their origin in the sea; but such is not the case, as they would then always contain a certain amount of salines, which are very rarely found in them.

The intermittence of other springs is due to the variations of the temperature of the atmosphere in the different seasons, and within the twenty-four hours. The "marvellous spring of Cashmere" only flows for fifteen days, in the month of May, when the snow melts, and is quite dry during the rest of the year, unless violent rains should occur, when it flows at irregular intervals. During those fifteen days it flows three times daily, and each time for three quarters of an hour. We have already seen, that many glacier springs flow in summer, and subside in winter; some of these disappear and reappear every day, the sun not being sufficiently powerful to melt ice in such quantities as would supply the spring during the whole twenty-four hours. A spring of the latter kind is the Engstlenbrunnen, in the Haslithal, in the canton of Berne, which flows from the middle of May until the middle of August, and then only from 4 o'clock P.M. till 8 A.M.; but if the season is cold it does not flow at all. Another cold spring, near Leuk, flows only from June to the beginning of September. The thermal springs of Pfäffers, in the

canton of St. Gallen, and which come from the glaciers of the Grison Alps, from a height of 8600 feet, and furnish a large amount of water at a temperature of 98° F., appear in May, and disappear in September. Pliny remarks in his natural history, that during summer the source of the Po dries up in the middle of the day; but although there are great variations in the quantity of its water, caused by the melting of the snow or heavy rains, there is, at least at the present time, no daily diminution of the water in it.

The intermittence of many other springs can neither be ascribed to the influence of the tides, nor to the variations in the temperature of the atmosphere. A spring at Paderborn, in Westphalia, discharges water twice in twenty-four hours, the discharge being accompanied by a loud rumbling noise. The Polterbrunnen, at Altenbecken, near Detmold, issues with great noise every six hours in summer, and every four hours in the other seasons; it flows for fifteen minutes, and then disappears. The ground occupied by the lake of Zirknitz, near Trieste, gives a crop of hay in summer; but towards autumn it is inundated with water from a spring, which rises in a neighbouring limestone cavern. In Pliny's time, the cold spring of Dodona, in Epirus, near Jupiter's oracle, dried up at noon, reappeared towards evening and became full at midnight, for which reason it was called *ἀναπαυόμενον* (intermittent). Springs of the same kind in this country are those of Giggleswick, near Settle, in Yorkshire, and Tideswell, in Derbyshire. The cave of Kilcorney, County Clare, in Ireland, which is gen-

erally dry, suddenly discharges a flood of water two or three times in the year. A spring near Colmars, in Provence, flows with intervals of seven minutes; it lost this peculiarity by the earthquake of Lisbon, in 1755, but regained it after another earthquake, in 1763. A spring at Fonsanches, near Nismes, in France, flows for seven hours, and is at rest for five. Finally, there is the celebrated spring near the villa Pliniana, which flows into the lake of Como, and which has for many centuries ebbed and flowed three times a day*.

The following is the cause of these phenomena. There are syphonlike canals in the interior of the earth, connected with collections of water, which are alternately empty and full. As soon as the water in a syphon has reached the top of the tube, it flows out; the quantity of water is thereby diminished, and it therefore ceases flowing, after it has sunk back below the level, at which alone it can overflow. As soon as, by the percolating moisture, the reservoir is again filled up to a certain

* The Princess Belgiojoso, to whom the villa Pliniana now belongs, has caused the words, in which Pliny, in his letter to Sura, (Epistol IV. 30) describes this spring, to be engraved on a marble tablet, both in Latin and Italian. They are as follows:—"The nature of this spring which falls into the Larian lake, is extremely surprising: it ebbs aud flows regularly three times a day. This increase and decrease is plainly visible, and very entertaining to observe. You sit down by the side of the fountain, and whilst you are taking a repast and drinking its water, which is very cool, you see it gradually rise and fall. If you place a ring or anything else at the bottom, when it is dry, the stream reaches it by degrees, till it is entirely covered, and then again gently retires from it; and this you may see it do three times successively."

point, the spring reappears. The intervals at which these springs flow, are proportionate to the quantity of precipitated and percolated meteoric water. If the cavity becomes rapidly refilled, the intervals are short; and if slowly, they are long.

There is yet another cause for the intermittence of springs, namely the tension of the carbonic acid and steam, with which many of them are charged. In the interior of the earth, water is under a powerful hydrostatic pressure, and may, therefore, even if hot, become impregnated with a large quantity of carbonic acid; but as soon as it has risen to the surface, the pressure ceases, and the gas, therefore, escapes with great force, so that a jet of water is driven up; which is especially remarkable, if the water comes from a great depth, and has a high temperature. As soon as the tension of the gas is diminished, the jet ceases, but spouts forth again, when the gas has acquired new tension. The Sprudel at Carlsbad spouts eighteen to twenty times in a minute, and rises from four to eight feet. The new Sprudel, at Neuenahr, in Rhenish Prussia, rises to a height of from twenty to twenty-five feet, with interruptions of three quarters of an hour. If in consequence of inundations, or other untoward circumstances, ordinary water mixes with such springs, their tension is immediately weakened, and the spout becomes smaller, or even entirely disappears; as was the case in Nauheim, in December 1854.

The phenomena of intermittent springs may be seen in all their magnificence in Iceland; where about

fifty springs at boiling heat exist in an area of a few acres; and which have been described by Krug von Nidda, Garlieb, Ohlsen, Descloiseaux, Sartorius von Waltershausen, and R. Bunsen. The great Geyser has small and large eruptions; the former take place about every two hours, when the water rises to a height of from fifteen to twenty feet; while the large eruptions are only observed every twenty-four to thirty hours when the column of water spouts more than a hundred feet high, has a diameter of eight feet, and is enveloped by immense clouds of steam. This eruption lasts for a few minutes only. The old Strockr spouts every four or five minutes; the Bubu-spring every second, and the new Strockr has one large eruption every two or three days, when the water and steam rise to several hundred feet, during a time varying from 45 to 130 minutes. The eruptions of the small Geyser take place at regular intervals of three hours and forty-five minutes. The chief eruption occurs between 9 and 10 A.M., and lasts for about twenty minutes. The eruptions of these springs are preceded by a tremendous subterranean roar; at first the jets rise but slightly and disappear again; they afterwards gradually ascend, until they reach their maximum, when they again slowly diminish, and at last entirely disappear.

Professor Bunsen, of Heidelberg, has given a very satisfactory explanation of these phenomena. According to him, the water of these springs contains a large amount of silica in solution, which, in consequence of the evaporation of the water, is precipitated, and forms

artificial tubes through which the springs rise. The large Geyser has a cylindrical tube, chiefly consisting of silica, and sixty feet deep and nine feet wide; but at its upper end, the tube enlarges so much, that it forms a basin with a diameter of fifty feet. Immediately after an eruption, this basin appears empty, the water having fallen four to six feet below the opening of the tube. Several hours elapse before this is refilled, as the basin is very wide. By its contact with the atmosphere, the water becomes considerably cooled at the surface; and on running back into the tube, it lowers the temperature there far below boiling point. Within the tube, the heat differs according to the depth, and to the time that has elapsed after an eruption. At the surface the temperature is at 184° immediately before the jet begins to rise; fifteen feet lower down it is 232°, and at a depth of thirty feet it is 251°. It is, therefore, not difficult to understand, why there should be a period of rest after an outbreak. The boiling point for water which is under a pressure of an additional atmosphere, is 250°; so that, as the water in the tube of the Geyser has a temperature of 251° at a depth of thirty feet, it would be just boiling there. Steam-bubbles are consequently formed and carried upwards; but as they, on rising, encounter a stratum of water which is below boiling point, they are at once condensed. This process is incessantly repeated for several hours before the eruption; and a fresh supply of heat from below is necessary to make the upper strata of water boil. These latter become continually hotter, as steam-bubbles con-

tinue to rise; larger quantities are forced upwards, until at last water and steam spout forth in a powerful jet which, on coming in contact with the atmosphere, is again cooled, and the tension of the steam thereby diminished. All the boiling springs of Iceland are fed by the meteoric water precipitated on the neighbouring hills, and derive their high temperature from the hot vapours rising from the interior.

The quantity of water furnished by springs is very different. The Winfred-spring, at Holywell, in Flintshire, discharges 1,900,000 cubic feet; those of Vichy from two to three millions of cubic feet; those of Carlsbad three millions; the artesian well at Grenelle 3,200,000; the springs of Cauterets more than four millions; those of Bagnères de Luchon five millions and a half; those of Aix-la-Chapelle seven millions; those of Leuk $17^3/_4$ millions; those of Teplitz twenty millions; those of Gastein forty-nine millions; a cold spring near Trieste 73 millions; the new artesian well at Passy, near Paris, 234 millions; the springs of Canstatt, in Würtemberg, 292 millions, and a brook near the lake of Laach 512,460,000 cubic feet of water annually.

In some springs the quantity of water is very variable, while in others it is more constant. Variations occur especially in the ordinary mountain-springs, which are more immediately dependent upon the amount of meteoric water that is precipitated. Springs which derive their origin from lakes and rivers, are dependent upon the quantity of water contained in these, and may

also show variations in consequence of a narrowing or widening of their outlets. On the whole, mineral springs supply a very constant amount of water. The measurements which have been made at Gastein, Teplitz, Wiesbaden, Mont d'or, and other Spas, under the most varied conditions and at very different times, have always given similar results; but at Vichy, Driburg, Bains-près-Arles, and other places, it has been observed, that the springs, after heavy rains, yielded an increased quantity of water, which at the same time became chemically changed; and in other Spas, the amount became augmented, while the chemical composition of the water remained unaltered.

Earthquakes generally produce great changes in ordinary as well as in mineral springs. They have sometimes caused springs to disappear temporarily or permanently; and, on the other hand, have given rise to new springs. On the day of the earthquake of Lisbon (November 1, 1755) all springs on the northern coast of Africa disappeared; those of Teplitz, according to Dr Ambrozzi, flow more copiously ever since this earthquake; during it they became muddy, were, for one hour and a half, of a dark yellow colour, and towards midday entirely disappeared for six or seven minutes; they then suddenly gushed forth again with great violence, so that all the basins overflowed; and for half an hour continued to emit a thick yellowish red water. On the same day the springs of Buda disappeared for forty-eight hours, and those of Salins, in Savoy, altogether. After the earthquake of Isernina, near Naples,

on the 26th of July 1805, the Sprudel at Carlsbad disappeared for several hours. Such alterations are evidently caused by the opening and closing of fissures, the formation of new cavities, and the interposition of porous or impervious layers, by which the passage of the water is retarded or entirely obstructed. If new springs appear after an earthquake, it is due to rocks being torn asunder, whereby an outlet is provided for water which had been imprisoned before. Thus, after the earthquake of Lisbon, a new warm spring issued at Neters, in Wallis. In 1784 all the thermal springs of Iceland were violently agitated, and thirty-five fresh springs appeared, which soon afterwards subsided. After the earthquake of 1692, the quantity of water yielded by the Pouhon, at Spa, became increased; and in May 1850, during a violent earthquake in Messenia, a boiling spring, with a strong sulphurous smell, rose at the foot of a volcanic cone. Occurrences of this kind have also been noticed in antiquity; Strabo relates that the Arethusa spring in Euboea was dried up by an earthquake, and after many days reappeared in another place; and after an eruption from a volcano, hot sulphurous springs broke out in Methana, in Greece, at the time, when Antigonus, son of Demetrius, reigned in Macedonia.

CHAPTER II.

THE PHYSICAL PROPERTIES OF MINERAL WATERS.

In this chapter I intend discussing the temperature of mineral waters, their electrical properties, their colour, and their relation to the ray of light.

I. TEMPERATURE.

Temperature exercises a very important influence upon the condition of the solid and gaseous constituents contained in mineral waters, as well as upon their action in the human body. A low temperature enables the springs to hold in solution a large quantity of carbonic acid, and consequently to take up a considerable amount of the carbonates of lime and magnesia, protoxide of iron, and other substances which are otherwise insoluble; while, on the other hand, a high temperature not only renders certain salines more soluble, but increases the active powers of the waters, and renders them more stimulant, often indeed to such a degree that it is necessary to let them cool before they can be taken by delicate patients.

The temperature of springs has a very extensive range. The Styx, in Arcadia, the Castalian spring, at Delphi, and a well near Irkutsk, in Siberia, are just

above freezing point; while the Geysers in Iceland, and the Urijino in Japan, are at boiling heat; and there is no degree of temperature between these two extremes, that does not answer to some spring. Many attempts have been made to classify springs according to their temperature, but without success. Thus Wetzler* has divided them in cold springs, at a temperature of 0°–15° R. (32° to 65°.75 F.), cool springs of 15°–20° R. (65°.75 to 77° F.) tepid, of 20°–25° R. (77°–88°.25 F.) warm of 25°–30° R., (88°.25–99°.5 F.) and hot springs, of 30°–80° R. (99°.5–212° F.).

In geology all springs are considered warm or thermal, the temperature of which exceeds, however little, the mean annual temperature of the place at which they rise; and such cold, as are below that temperature. This has the inconvenience that we have to call a spring in one country warm, which may be seven or eight times colder than one in another country, which is considered cold. The mean annual temperature for a large portion of Germany, France, Belgium and England is about 50° F.; an isothermal line of 50° runs through the South of Ireland, where Dublin is at 49° and Cork at° 51; thence passes to England, where Liverpool is at 49°, Plymouth 51°.8 and London 49°.6; runs over to France, where Paris is at 50°.9; to Belgium, where Brussels is at 50°.9; to Holland, where Haarlem is at 50° and Amsterdam at 49°.6; thence passes to Germany, where Münster is at 49°, Düsseldorf at 49°, El-

* Ueber Gesundbrunnen und Bäder. Mainz 1819. Vol. I. p. 135.

berfeld at 48°.3, Treves at 49°.6, Metz at 50°.5, Frankfort at 49°.6; and runs by way of Mannheim, Heidelberg, Karlsruhe and Würzburg to the South of Bohemia and Moravia, Prague being at 49°.3; it then proceeds to Vienna, which is at 50°.9, to the North of Hungary, where Pesth is at 51°, and finishes on the shore of the Black Sea. On the other hand, the mean annual temperature is only 38° at St. Petersburg, and only 19° at Irkutsk, while on the banks of the Orinoco it amounts to 82°. A spring of 34° will therefore be considered warm at Irkutsk, and cold at most other places; one of 40° will be called warm at St. Petersburg, while one of 80° would be considered cold in the Equatorial regions. It seems to me, therefore, that it would be more philosophical to make the heat of the blood, which is invariable and not influenced by climate, latitude and elevation, the standard, and to consider such springs, as are above 98°.3, warm, and those which are below it, cold. But as the former division has been generally accepted, it is, perhaps, best to adhere to it. In the following a tabular view of the temperature of some of the more important springs is given.

TABLE I.

33°–50° F.

Places.	Names of Springs.	Temperature.
Nonacris, Arcadia	Styx	33°
Montblanc		33°.4
Engstlenalp, Berne		38°
Rigi-Kaltbad		41°
St. Moritz, Upper Engadin	Old Spring	42°
Tarasp, Lower Engadin		45°.5
Luhatschowitz, Moravia	Vincenzquelle	47°
Krankenheil, Bavaria	Annaquelle	48°
Reinerz, Silesia	Kalte Quelle	48°
Salzbrunn, Silesia	Oberbrunnen	48°
Brückenau, near Kissingen		49°.5
Schwalbach, Nassau	Weinbrunnen	49°.5–50°
Nenndorf	Schwefelquelle	50°
Homburg	Elisabethbrunnen	50°
Rippoldsau, Baden	Josephsquelle	50°
Geilnau		50°
Fachingen		50°

TABLE II.

51°–75° F.

Places.	Names of Springs.	Temperature.
Driburg, Westphalia	Eisenquelle	51°
Kissingen	Ragoczy	51°
Kissingen, Bavaria	Maxbrunnen	51°.5
Spa, Belgium	Pouhon	52°
Franzensbad	Salzquelle	52°.5
Marienbad	Kreuzbrunnen	53°
Bilin	Josephsquelle	53°.4
Pyrmont	Trinkbrunnen	54°.5
Wittekind, near Halle	Soolenquelle	54°.5
Kreuznach, Rhenish Prussia	Elisenquelle	54°.5
Eilsen	Schwefelquelle	59°
Kronthal	Stahlquelle	59°
Saidschütz	Bitterwasser	60°
Achselmannstein	Edelquelle	61°
Meinberg, Lippe-Detmold	Schwefelquelle	61°
Selters		62°
Reinerz, Silesia	Laue Quelle	62°
Vichy	Fontaine des Célestins	67°
Lippspringe, Westphalia	Arminiusquelle	70°
Soden	Milchquelle	75°

TABLE III.

76°–100° F.

Places.	Names of Springs.	Temperature.
Teplitz, Bohemia	Trinkquelle	80°
Landeck	Wiesenquelle	81°.5
Buxton	Gentlemens bath	82°
Bristol	St. Vincent	84°
Ems	Krähnchen	85°
Schlangenbad		87°
Nauheim	Soolsprudel	90°.5
Rehme	Soolquelle	91°
Eaux bonnes	Fontaine vieille	91°.5
Eaux chaudes		93°
Courmayeur		93°
St. Sauveur		95°
Wildbad, Würtemberg	Fürstenbad	96°.3
Baden, near Vienna	Schwefelquelle	96°.8
Pfäffers		98°
Carvalhal, Portugal		99°
Benetutti, Sardinia		100°
Tiflis	Nicolaispring	100°

TABLE IV.

100°–125° F.

Places.	Names of Springs.	Temperature.
Oasis El Daghlee, Sahara		102°
Warmbrunn, Silesia		104°
Vichy	Grande Grille	108°
La Preste	Fontaine Apollo	111°
Thermopylae, Greece		111°
Torres vedras		111°
Pozzuoli		111°
Gastein	Doctorsquelle	111°
Barèges		113°
Carlsbad	Schlossbrunnen	113°
Pisa		113°
Aix-la-Chapelle	Corneliusquelle	114°
Aix-les-Bains	Alumspring	116°.4
Cauterets	Fontaine de César	118°.4
Bath	Kings bath	119°
Teplitz	Hauptquelle	120°
Gastein	Hauptquelle	120°
Baden, Switzerland		122°
Bagnères de Bigorre		122°
Guitera, Corsica		122°
Leuk, Switzerland	Hauptquelle	125°

TABLE V.

126°–150° F.

Places.	Names of Springs.	Temperature.
Lucca		129°
Emaus, Syria		130°
Aix-la-Chapelle	Kaiserquelle	131°
Carlsbad	Theresienbrunnen	131°.5
Chaudes Aignes	Filgères	133°
Ems		133°
Bagnères de Luchon		133°
Borcette, Rhenish Prussia	Trinkquelle	135°.5
Mehadia, Banate	Herculesquelle	144°
Amélie-les-Bains	Fontaine Arago	145°
Plombières	Fontaine du bain Romain	149°
Smyrna	Agamemnons' spring	150°

TABLE VI.

151°–212° F.

Places.	Names of Springs.	Temperature.
San Pedro Dosal, Portugal		154°
Baden-Baden	Hauptquelle	155°.5
Wiesbaden	Kochbrunnen	156°
Arles		160°
Carlsbad	Sprudel	164°.35
Segesta, Sicily		165°
Borcette	Heisse Quelle	171°.5
Abano, Lombardy		181°
Aedepsos, Euboea		183°
Aigues Chaudes		185°
Reikiavik, Iceland		188°
Oletta, Roussillon		190°
Mescutin, Algeria		200°
Ischia	Aqua del Olmitello	201°
Chichimaquillo, Mexico		205°
St. Michael, Azores		208°
Urijino, Japan		212°
Iceland	Geyser and Strockr	212°

The great heat of many springs, even of such as issue at high elevations and from under ice and snow, has long been a subject of wonder and speculation, and has only recently been explained. There can be no question as to *where* the heat is imparted to the springs; for if their mean temperature is much higher than that of the place where they rise, the water must have been heated in the interior of the earth; since atmospheric moisture, to which the springs owe their origin, is, when precipitated, of low temperature. But the influence *by* which the springs acquired their heat, has until very lately formed the subject of discussion. Many philosophers believed it to be due to volcanic agency; but some of the hottest springs are found in countries where volcanoes do not exist. Duclos, who wrote at the end of the 17th century, remarked, that there were many thermal waters in France, but no volcanoes; and Baron Humboldt discovered, during his journey in South America, the hot springs of las Trincheras, in Venezuela, which have a temperature of 194°, and those of Comangillas, at 205°, both of which are at a great distance from volcanoes; while others in the same country, which are close to the active volcanoes of Pasto, Cotopaxi, and Tunguragua, have only a temperature of 97° to 129°. There can, however, be no doubt that there is a connexion between volcanic phenomena and the temperature of such springs *as issue in volcanic districts,* of which more will be said hereafter.

Another opinion was that the springs were heated by subterranean fire. This theory of a central subter-

raneau fire which was perpetually burning, and imparted heat to the mineral waters, was first laid down by the Greek philosopher Empedocles. Vitruvius, a contemporary of Cicero, said, that this fire was lighted by alumina, bitumen and sulphur, and that by its action part of the water was changed into vapour. More recently, Becher stated his belief, that the waters of Carlsbad flowed over burning iron-pyrites; and Klaproth endeavoured to prove, that the water was heated by an immense bed of coal which was set on fire by iron-pyrites.

The geological condition of the soil, from which the springs issue, does not seem to exercise much influenceupon their temperature, as thermal waters rise from all kinds of formations, such as granite, mica, basalt, trachyte, porphyry, greenstone and greywacke. Artesian wells which have always a higher temperature than that of the place where they come forth, are also independent of special geological conditions. It is, however, worthy of remark that springs, which are very hot, rise generally from or below granite.

Many philosophers have sought the cause of the heat of thermal springs in chemical processes. Paracelsus remarked that certain minerals were burned by the air, and thereby caused heat.* Henri de Rochas believed this to be due to the chemical combination of salts and alkalies. More recently Leopold von Buch

* "Multa sunt mineralia quae ab aere incendentur." (De aquis mineralibus 1562.)

endeavoured to connect the heat of springs with the oxidation of alkaline metals by water. No doubt heat is produced if potassium, sodium, lithium, and other similar metals, are oxidised and hydrogen is set free; but even if they existed in the interior uncombined with oxygen, and came in contact with water and sulphuric, hydrochloric, and carbonic acids, so that sulphates, chlorides and carbonates (compounds which are contained in many mineral waters) were thereby formed: the temperature would even then be only slightly increased and by no means come up to the degree of heat actually possessed by a number of springs. Another objection to von Buch's theory is, that streams of hydrogen, which would necessarily be developed by such processes as he assumed to take place, have never been observed to issue with the water; nor is the heat of springs at all proportionate to the quantity of salines found in them. Many springs which contain a very large amount of solid ingredients, are cold; and the Spas of Gastein, Wildbad, and Pfäffers, which have a very elevated temperature, contain scarcely any fixed constituents. M. Boussaingault has contended that the thermal springs which rise from the granite of the Cordilleras, derived their heat from the action of water upon sulphuret of silicium; but if such were the case, the springs mentioned would contain a large amount of silica and sulphuretted hydrogen, neither of which are found in them. Another supposition was, that the heat was caused by the combination of water with quicklime; but as hydrate of lime, which would thereby

be formed, is not found in a number of springs which have an elevated temperature, we must also reject this hypothesis. Besides, Bischof has shown, that all endeavours to explain the heat of springs by chemical processes, must remain unsatisfactory, because it is impossible to conceive how such processes should continue for such lengthened periods, and with such uniformity, as would account for the uninterrupted course of springs, their constant productiveness, and their unvarying temperature. Certain substances are no doubt oxidised in the water, and heat is consequently developed; thus protoxide of iron is changed into peroxide, and organic matter transformed into carbonic acid, by the free oxygen contained in the water; but the quantity of this gas which is present is so trifling, that only very little heat can thereby be imparted to the water; especially as other and more extensive chemical processes by which cold is produced, continually take place in it, whereby the small increase of heat, which may have been generated, is again counterbalanced. Thus for instance, the solution of salines is always attended with a decrease of temperature, which is more or less considerable according to the quantity of salines dissolved.

Leopold von Buch believed another cause of the heat of springs to be the absorption of carbonic acid by water; to which conclusion he was led by his observations on the springs of the Canary Isles. It is true that carbonic acid, when subjected to a considerable hydrostatic pressure, causes an increase of tem-

perature in the water in which it is dissolved. But the researches of Henry and Bischof have proved, that the elevation of temperature by the absorption of even large quantities of carbonic acid, is very insignificant, and by no means sufficient to account for the great heat possessed by many mineral waters. Besides the fact is incontrovertible, that by far the greater part of acidulous springs exceed the temperature of fresh water springs in their neighbourhood by one or a few degrees only, while several of them are even colder than freshwater springs. Finally we must consider that, as soon as the water comes in contact whith the atmosphere, the greater part of the gas previously absorbed by it, escapes; with the effect that the small amount of heat thus generated is lost again.

It is not the object of the present work to consider in detail all the theories which have been propounded on this subject; and I will only revert to one other recently brought forward by M. Anglada, who thought that the heat of springs was to be accounted for by the action of electromotors in the interior of the earth; but if this supposition were correct, springs rising in the vicinity of beds of magnetic iron-ore, must always have an elevated temperature, which is by no means the case. All the theories I have hitherto mentioned seek the cause of the heat of springs, not in an agency present everywhere, but in certain peculiar circumstances. M. Anglada has, indeed, endeavoured to show that this must be so, because thermal springs were not universally distributed, but were found grouped to-

gether in particular places. This argumentation, however, cannot be sustained; for, although hot springs, in the common acceptation of the term, are not very frequent, still thermals in the geological sense of the word, are found in all latitudes and climates, and in many places they are even more abundant than cold springs. The great majority of the mineral waters of the Westerwald and Taunus mountains, surpass the mean annual temperature of the places where they issue. M. Wille has determined the temperature of thirty groups of Spas between the Taunus and Vogelsgebirge, and found all of them to be thermals. The numerous saline springs in Prussia, between the Elbe and the Rhine, have an invariable temperature, which exceeds that of the atmosphere by from 4° to 14°. The same is the case with many springs rising in the Erzgebirge, the Riesengebirge, in Moravia, Bohemia, Hungary, Transylvania, Slavonia, Croatia, and on the declivities of the Caucasus. A large number of thermals are met with in Austria, Carniola, Carinthia, Styria, the Tyrol, and Switzerland. In France we find a chain of warm springs extending from the mountains of the Vosges to the Pyrenees; and in Italy, Sicily, Spain, Portugal, and Greece, they are innumerable. Indeed such springs are not confined to any particular formations of the soil, but are found in the youngest secondary strata as well as in the oldest neptunian and volcanic rocks. We find them in every part of the globe, and they rise below the level of the sea, a few hundred feet above it, and even at heights varying from 1000 to 14000 feet. All this

justifies the conclusion, that the high temperature of thermals must be due to a cause existing everywhere; and which is now almost universally admitted to be the heat inherent to the interior of the earth.

The first who divined the true cause of the high temperature possessed by many springs, was Patricius, the learned bishop of Pertusa, who lived in the third century A.C., and who, when questioned by the Roman Proconsul Julius as to the origin of the heat of the springs of Carthage ("quo auctore fervens haec aqua tantum ebulliat") answered, that it was the same heat, which caused the eruption of Vesuvius and Etna, and which imparted warmth to the springs in proportion to the depth of their origin. Subterranean waters which were distant from the seat of the fire, were cold, while those close to it carried an insupportable heat to the surface. It was, however, only very lately that proofs for the correctness of this view were adduced. Kircher, a German philosopher, was the first to notice that in mines the temperature increased with the depth *. The mining officers of Schemnitz, in Saxony, remarked to him, that in the pits they did not suffer from either heat or cold, so long as ventilation was properly carried out; but as soon as the circulation of air was impeded, the heat became considerable. Scientific observations of the temperature in mines were only undertaken from the middle of the last century, when they were made especially in the leadmines of Giromagny

* Mundus Subterraneus. 1664 vol. II. p. 184.

in the Vosges (from 1740); in the silver and leadmines of Brittany; in the coalpits of Nièvre; in the saltmines of Bex, in Switzerland, and in Freiberg, in Saxony (from 1791); in the mines of Mexico and Peru, at the commencement of this century, by Baron Humboldt; in the copper and leadmines of Cornwall and Devonshire (from 1815); in the Prussian mines (from 1828) &c. &c. All these observations have incontrovertibly established the fact, that the heat of the interior increases in proportion as we descend; but it has been found impossible to deduct from them a general law of the rate of increase of the terrestrial temperature. In mines there are many foreign influences at work, which determine the degree of temperature, and do not allow of an accurate estimation. In the first instance, the temperature of the atmosphere considerably disturbs such observations. When shafts communicate with adits, and free access of air from without is allowed, the heat of the interior in thereby more or less diminished according to the seasons of the year, the time of day, the wind which agitates the air, and the manner in which ventilation is carried out in the several galeries and shafts. On the other hand, the exhalations and lights of the pitmen, cause an extraneous increase of heat. Laplace therefore endeavoured to ascertain the increase of temperature by carrying borings down to different depths, and noting the temperature at all points of progress; and Arago was the first to perceive, that artesian wells were peculiarly adapted to the determination of these phenomena. The temperature of ar-

tesian wells is always higher than that of the place where they issue, and is proportionate to the depth from which they rise. Thus the well at Rüdersdorf, near Berlin, is 880 feet deep and has a temperature of 65°.8; that of Grenelle, near Paris, is 1600 feet, and 81°.8; that of Passy is 1731 feet and 82°; that of Neusalzwerk, near Minden, in Prussia, is 2094 feet and 89°; and that of Mondorf, in Luxemburg, 2278 feet and 108°.5. From these and similar observations Arago has drawn the following conclusions:—as we approach the centre of the globe, the terrestrial temperature steadily increases; after a certain depth it is independent of any changes in the temperature of the atmosphere, and in fact, invariable; and the increase of heat is at the rate of 1° F. for every 51 feet.

The temperature of the immediate surface of the soil is nearly identical with that of the atmosphere, and differs only according to day or night, the seasons, the latitude, and the elevation above the level of the sea. But as earth is a bad conductor of heat, the sudden changes which occur in the temperature of the atmosphere, are necessarily confined to the surface of the soil. At a depth of from two to six feet, the daily and weekly variations are no longer perceptible, and it is only the great periodical changes, the yearly maxima and minima of the temperature, which may still be perceived at a further distance from the surface; and sixty feet is the utmost limit to which these changes extend. The thermometer in the cellars of the Paris observatory, has for more than fifty years been invariably at 53°.3 F.

The depth to which the temperature of the atmosphere continues to exert its influence, is not everywhere the same; but differs according to the amount of the variations of the temperature of the air, and to the different degree of conducting power possessed by the earthy and rocky strata of which the crust of the earth is composed. Thus, while at Paris the influence of the air extends to about thirty feet, the temperature of the soil is, between the tropics, invariable at one or two feet below the surface; and at Jakutsk, in Siberia, the earth is, in winter, frozen at a depth of 630 feet. Between the tropics, hot springs with a constant temperature may, therefore, rise from a depth of four or six feet, while in our latitude no thermal spring exists which does not come from a depth of at least sixty or eighty feet; and a spring of 34°, in Siberia, ascends from a greater depth than one of 100° in the equatorial regions. The greatest depth from which springs can ascend, is 8000 feet below the surface, as there the heat is so considerable that water must be at boiling point.

With every foot we descend, the amount of the variations of the temperature is diminished. In the middle of Europe the difference between maximum and minimum amounts, at a depth of six feet, to 20° or 22°. In most places it is only 1° at a depth of thirty-six feet, and in others no variations whatever are to be observed there.

The changes of temperature in the upper strata of the soil do not occur simultaneously with, but only

some time after, those of the atmosphere. In our latitudes it takes about a month's time for the temperature of the air to penetrate to a depth of six feet; two months to reach a depth of twelve feet &c.; so that the temperature of those springs which flow in superficial layers, is at its maximum, not in summer, but in autumn.

The theory being established that water which comes from a considerable depth, is warm, while that which rises from superficial strata, is cold, we are now enabled to explain almost all phenomena connected with the temperature of mineral springs, and even such as were formerly believed to be most mysterious and unaccountable. Thus, for instance, it has perplexed many inquirers, why hot springs should rise in close proximity to others which are cold. This is the case at Eaux Bonnes, in the Pyrenees; on St. Michael, one of the Azores, where a cold spring rises close to one which is nearly boiling. Homer has described the two springs of the Scamander, near Troy, one of which was warm and steaming, while the other was even in summer as cold as ice*. In Strabo's time the warm spring of the

* "Next by Scamander's double source they bound
Were two fam'd fountains burst the parted ground;
This hot through scorching clefts is seen to rise
With exhalations steaming to the skies;
That the green banks in summer's heat o'erflows,
Like crystal clear, and cold as winter snows;
Each gushing fount a marble cistern fills,
Whose polish'd bed receives the falling rills."

Pope's Iliad XXII. 147—156.

Scamander had disappeared; but a recent traveller has again found both close together. Chandler mentions that a cold spring rises in the immediate neighbourhood of Agamemnon's bath, near Smyrna, which has a temperature of 150° F. Such phenomena are easily understood, if we consider that cold springs rise from superficial strata, and have a temperature approaching that of the atmosphere; while thermals come from a more or less considerable depth, both having entirely different channels, and only accidentally bursting forth close to each other.

As it appears from Arago's researches that the temperature of the crust of the earth regularly increases in proportion as we approach the centre of the globe, it would seem easy to deduce from the temperature of mineral waters the exact depth from which they rise. But calculations of this kind, when made for artesian wells previous to the appearance of the water, have frequently proved erroneous; their temperature being sometimes higher, and sometimes lower, than was to be expected from the depth to which the boring had been carried. Thus the artesian well of Passy, which is 1731 feet deep, might be expected to have a temperature of 85°.3, as Paris has a mean annual temperature of 50°.9; but it is only 82°; while the well of Mondorf, in Luxemburg, which is 2278 feet deep, and should therefore have a temperature of 95°, is in fact at 108°.5. If the water is hotter than was expected,

* Travels in Asia minor and Greece. Oxford 1825. Vol. I. p. 104.

this is due to the circumstance that water coming from a greater depth, and therefore imbued with a more considerable heat, mixes with the water contained in more superficial layers, and thus imparts to it a higher temperature than it originally possessed. If, on the other hand, the temperature is lower than might have been expected, the reason for this is, that water flowing higher up, mixes with that contained in the deep strata, and cools it in proportion. It would, therefore, be a useless task to calculate the depth of the origin of mineral springs from their temperature. In nature one cause seldom acts without the simultaneous concurrence of others, whereby the phenomena become complicated; and errors are, therefore, sure to follow if only one agency is taken into consideration.

I now proceed to examine the influence exercised on the temperature of springs by other causes than the terrestrial heat. Where the water does not slowly filter through the ground, as is mostly the case, but, on the contrary, runs in considerable streams through fissures, crevices &c., the temperature of the meteoric water at the time of its precipitation is of importance, and may cause perceptible changes in the temperature of springs in the different seasons of the year. In the great majority of cases, however, the temperature of the meteoric water does not exert much influence, at it is lost in the inexhaustible supply of subterranean heat. The meteoric water, to which thermal springs owe their origin, encounters, in its way downwards, immense accumulations of hot water, in which only very trifling var-

riations of temperature can take place, even if the fresh additions to it from above should be very large. The variations in the temperature of such springs as rise from moderate depths, seldom amount to more than 7°, while that of most thermal waters is constant.

The temperature of springs is also somewhat influenced by the elevation at which they have their source. They carry cold with them, if they come from high elevations, if they yield an abundant quantity of water, andif their subterranean course is superficial, unchecked and rapid. In high elevations not only the atmosphere, but also the layers of the soil through which the water passes, are cold, and they therefore abstract a greater or less amount of the caloric which the water originally possessed. Springs which derive their origin from glaciers and lakes at great heights, have a low temperature, which is however not so low as might be expected from the circumstance that they originate in melted ice and snow. On the other hand, such as are supplied by sunken rivers, are warm if the water has reached a great depth, or has come in contact with a volcanic focus. Baron Humboldt mentions a volcano in Mexico, which, in September 1759, suddenly rose as a cone of 1588 feet above the surrounding plain; at the same time two small rivers, the Rio di Cuitimba and the Rio de San Pedro, disappeared; but some time afterwards they returned, accompanied by frightful concussions of the earth, as hot springs, which, in 1803, had a temperature of 180°.

Mountain springs which rise at a considerable height,

are mostly very cold; but the temperature of the ascending thermal springs is generally only little influenced by the elevation at which they issue. In Asia hot springs are found in the region of perpetual snow; nor is Europe devoid of thermal springs at great heights. The most celebrated of these are the hot springs of Leuk, in Switzerland, 4275 feet above the level of the sea, which have a temperature of 100°; and those of Warmbrunn, in Silesia, 3500 feet above the sea, which have a temperature of 104°. In a few instances, however, elevation seems to exercise a considerable influence upon the temperature of thermal springs. There is a chain of hot springs rising from the Cordilleras, in Venezuela, the temperature of which increases in inverse proportion to their height. Those of las Trincheras, near Puerto Caballo, which are only a little above the level of the sea, have a temperature of 206°; while the spring of Mariane, at a height of 1465 feet, is at 147°, and that of Onsto, 2161 feet high, is at 112°. Such a decrease in the temperature of thermals, according to their elevation, is, however, by no means the rule; and if a spring which issues at a very great height, rises from a considerable depth, it must, on that account, be warmer than one issuing at a lower level, but coming from a superficial layer of the soil. If several branches of one ascending spring come out at different heights, those which issue at the lowest points, will naturally have the highest temperature. At Bagnères de Bigorre, there are four springs, of which the two that issue lowest down, are at 124°; a third which comes to light

360 feet higher, is only at 115°; and a fourth, which rises between them, is at 118°. It is easy to understand why this should be so. Not only is there a greater length of soil through which the springs have to ascend; but this additional length is also colder, whereby the amount of heat withdrawn is still further increased. If the hydrostatic pressure is inconsiderable, so that the water is slowly forced through the soil, thermal springs lose more heat than if they are under a very powerful pressure, and, therefore, ascend rapidly. The loss of heat also depends upon the conducting power of the soil, through which the water runs. Springs may rise from the same depth, and nevertheless differ in temperature according as they flow through firm or porous soil, and through rocks which are good or bad conductors of heat.

The temperature of mineral springs generally increases if much water is drawn from them, as a larger afflux of water from below is hereby induced and the heat is then no longer so extensively absorbed by the surroundings of the springs, as is the case when only little water flows out. This is also the reason why thermal springs which generally discharge an abundant quantity of water, are hotter than such as throw off a lesser amount. Thus the principal spring of Gastein, which daily discharges 100,000 cubic feet of water, has a temperature of 118°; the Princes' spring of the same place, which only yields 15,000 cubic feet per diem, is at 115°.7; the Surgeons' spring, with 3840 cubic feet, at 111°; another which only throws off 960 cu

bic feet, is at 106°; and the smallest, with 800 cubic feet, is at 95°.

Springs lose their heat in the most marked manner, if so-called "wild water", that is, cold superficial springs, or rain water, mixes with them. For this reason, in many of the Spas which are used for medical purposes, careful contrivances are employed for preventing as much as possible such untoward accidents.

If the water of thermal springs is led to a distance by means of pipes, it loses caloric according to the length of the aqueduct, the conducting power of the material of which the pipes are made, and according as these are above or belowground. The water of Pfäffers, in Switzerland, is led down to the neighbouring Ragatz by means of wooden pipes, a distance of 12,506 feet, with a fall of 544 feet; the water runs from one place to the other in 43 minutes, and loses 4°.5 on the way. In the same manner the water of Gastein which has a temperature of 120°, is led by means of pipes which are partly above, and partly belowground, to Hofgastein, a distance of 26,876 feet, where the water arrives after two hours and a quarter, and has a temperature of 110°.

Volcanic agency which is closely connected with thermal springs, sometimes effects an increase in their temperature. Although warm springs are distributed over the whole surface of the globe, no matter whether the formation is volcanic or not, we nevertheless find them in greatest abundance wherever active volcanoes exist. In the environs of Naples numbers of them

emerge directly from the volcanic rocks and the limestone mountains connected with them; the same is the case in Stromboli, Sicily, Iceland and Java. In such places the crust of the earth is not only thinner than elsewhere, but also very much fissured, so that meteoric water easily accumulates in its strata and immediately assumes a high temperature. If the volcanic eruptions are unusually powerful, they often cause a sudden increase in the temperature of neighbouring thermals. Thus the heat of the steamspring of S. Germano, near Vesuvius, rises about 6°, if that volcano is very active; and the temperature of the springs of La Pisciarella, near Naples, has, under such circumstances, been observed to rise from 100° to 200°.

Earthquakes which not only tear the ground asunder, but also close fissures, have likewise a great influence on the temperature of springs, even at places which are at a considerable distance from the immediate scene of such catastrophes. If deep rents are made by the shocks, the meteoric water will sink to a greater depth, and thereby become hotter; on the contrary, if fissures are suddenly closed, the water is prevented from sinking so deep as before, and the spring becomes colder. Thus after the earthquake of Lisbon, the source de la Reine, at Bagnères de Luchon, acquired a higher temperature, while that of the springs at Bagnères de Bigorre suddenly fell. During the earthquake of 1768, the sulphurous springs of Baden, near Vienna, became hotter than they had been before. Those of Aix in Savoy became colder after the earth-

quake of 1822. The springs of Las Trincheras had, when discovered by Baron Humboldt, in 1800, a temperature of 194°; and in 1823, when visited by M. Boussaingault, they had risen to 206°. A terrible earthquake had taken place in the interval, which, on the 12th of March 1812, entirely destroyed the town of Caraccas; no doubt new fissures were at that time formed, which gave the water of the springs access to a greater depth than it had before.

Excessive heat or great cold, heavy rains or continued droughts have seldom much influence in altering the temperature of thermals; a few instances are, however, on record of changes induced by such circumstances. There is a spring at Evaux which, after heavy rains, falls from 113° to 50°; and the variations which have been observed in the temperature of the Vichy waters, are probably due to the same cause. The Grande Grille of that place has shown the following variations: in 1775 it was at 119°; in 1820 at 100°; in 1823 at 102°; in 1836 at 98°, in 1843 at 89°; in 1844 at 93°, and in 1861 at 108°5.

The temperature of thermals is, generally speaking, constant, and it is probable, that in most of them it has scarcely, if at all, varied for many centuries. The thermal springs from which Thermopylae derives its name, are now at 185°, and they were certainly not hotter than this at the time when Xerxes invaded Greece. The Aquae Calentes (Chaudes Aigues) which were used by the Romans two thousand years ago, are now at 176°. The baths of Mont d'or, which were resorted to

by Julius Caesar, are now at 110°, about the highest temperature which the human body is capable of sustaining unhurt. If a change of temperature should in the course of time be brought about, it seems more probable, that the heat increases rather than diminishes, especially in such springs as contain a considerable amount of salines; for as part of the solid constituents of the earth is continually brought to the surface, large caverns are formed, and the water thus gradually sinks to greater depths.

There are also some cold springs, the temperature of which seems neither to change with the seasons nor with time. Thus the water of the Styx, which has its source in the wild Alpine tracts of Arcadia, near Nonacris, where it dribbles from a steep rook, is as ice-cold now as it was in antiquity. The Greek writers affirm, that its coldness was such as to break all vessels, whether of glass, metal or any other substance, with the exception only of those which were made from the hoof of the ass. A German traveller, M. Schwab, who visited the Styx some years ago, found the water extraordinarily cold, but otherwise pure and pleasant to the taste. Perhaps it was this icy coldness, which may have sometimes been noxious to the wanderer, that gave rise to the belief in the poisonous qualities of Styx water, which was said to instantly destroy those who drank of it; or this belief, which even nowadays exists in Arcadia, may also have been caused by the terrible wildness and solitude of the locality in which

the spring rises, or by the myth of its origin from the Tartarus.

Another spring which was just above freezing point in antiquity, is the Castalian spring, which was in the enclosure of Apollo's oracle at Delphi, and in the icy water of which the Pythia had to bathe, before ascending the tripod. The spring has preserved this coldness up to the present time. Chandler who, on his visit to Delphi, washed his hands in it, was instantly chilled, and seized with a tremor which rendered him unable to walk or stand without support, so that he had to be carried to the monastery; he afterwards fell into a most profuse perspiration, an incident which at a time when Apollo was dreaded, might have given rise to superstitious interpretations*.

All springs with a variable temperature are coldest at the end of spring, and hottest towards the approach of autumn. Such of them as are subject to very considerable variations, and therefore follow closely the changes of temperature in the atmosphere, reach, in the northern hemisphere, their highest temperature at the end of August, while those, in which the variations are only trifling, are warmest at the end of September.

There are a few springs which, although their tem-

* Travels in Asia minor and Greece. Oxford 1825. Vol. I. p. 323. Dodwell, however (A classical and typographical tour through Greece. London 1819. Vol. II. p. 173) describes the Castalian water as a cold, but excellent beverage, and says that it produced none of those effects upon him, which were felt by travellers of more lively disposition and more delicate stomachs.

perature does not vary with the seasons, seem to have become colder in longer periods. Instances of this kind are the Pouhon, at Spa, and the Weinbrunnen, at Schwalbach. In considering this matter it must, however, not be forgotten, that until very lately scarcely any two thermometers were perfectly alike, so that the statements of the older inquirers regarding this subject are open to grave doubts.

Some springs show periodical variations of temperature which, in the present state of science, it is difficult to explain. One of these is the spring of the Sun, near the temple of Jupiter Ammon, in the oasis of Siwah, on the western boundary of Egypt, of which we are told by Herodotus that the water was lukewarm in the morning, cold in the forenoon, and coldest at noon; that it became warmer in the afternoon, and boiling towards midnight. This is also mentioned by Lucrece and Ovidius; and Herr von Minutoli, who has recently visited the spot, has affirmed that a change of temperature takes place in the spring, although it is not so considerable as it would appear, from the description of Herodotus, to have been in antiquity. Without wishing to disparage the observations of Herr von Minutoli, I may say that it is very desirable, that fresh and careful thermometric observations should be made on this spring. Another instance of periodical variations of temperature is a hot spring at Cannea, about seven miles from Trincomalee, where, without any visible cause, they amount to 3° or 4° in every two or three hours.

I now proceed to discuss the oft-mooted question, whether the heat of thermal waters is identical with ordinary heat, or whether the former possesses properties peculiar to itself. There are great authorities on both sides, as Hufeland, Rullmann, Patissier and others, asserted that there was a difference between the two; while Struve, Bischoff, Alibert and others, denied such to be the case.

The reason for first assuming a difference between ordinary heat and that of hot springs, was the circumstance, that the indifferent thermal waters, namely such as contain scarcely any solid ingredients, were proved to possess most remarkable curative properties, which did not belong to ordinary water of the same temperature. From this it was concluded that, until physics and chemistry could otherwise account for these effects, the peculiar kind of heat possessed by the Spas, must be considered the cause of their therapeutical powers. This opinion seemed to be the more plausible, as certain experiments, which were made on the nature of thermal heat, went far to prove that such a difference really existed.

On going back to the sources, it appears that Paracelsus was the first to originate the theory of a heat peculiar to mineral waters. But it was especially Duclos, Physician to Louis XIV, who first analysed the more important mineral springs of France, who supported such theories. He stated as the results of his experiments on this subject, that hot Spas did not burn the mouth and tongue to the same degree as wa-

ter heated by fire; that they had not the same action upon certain delicate substances, as common hot water; sorrel-leaves, for instance, which became soft and were easily cooked in ordinary warm water, did not soften in the thermal waters of Néry-en-Bourbonnais, which were the hottest in France; but if put in this, turned yellow, like dead leaves. Another remarkable circumstance was, that the thermal waters were hotter at night than in the day; and when exposed to the air at a distance from the springs, they lost their heat more slowly than water artificially heated. Finally, it took just as much time to make hot mineral water boil, as ordinary cold water. The explanations which Duclos gave of these phenomena, are, as might be expected, quite untenable: thus, for instance, he thought that thermal waters did not boil quicker than common cold water, because the fire had first to expel the hot vapours mixed up with them, before they could boil. However, as Duclos wrote in 1675, we must not criticize such explanations too severely, as they were quite consistent with the then state of physical science. But the same tribute cannot be paid to certain modern writers, who in their anxiety to maintain the mysterious character formerly attributed to mineral springs, have disregarded the most obvious physical laws, by which all phenomena connected with the temperature of mineral waters, may be satisfactorily explained.

In conducting experiments on the heat of thermal springs, several points ought to be borne in mind. In the first instance we must reflect that, if hot water

is allowed to cool in a vessel, it is influenced by conduction. If the water be contained in an open vessel, the heat is conducted immediately to the air, above; but below, and at the sides, it is first conducted to the supports of the vessel, and from thence into the air. The vessel and its supports remain as they are, and as far as they are concerned, it depends upon the power of conduction possessed by the substance of which they consist, and upon their greater or less thickness, whether the cooling will proceed slowly or rapidly. If the vessel is made of thick wood or glass, it will take some time to cool; but if it is formed of thin metal, it will cool rapidly, although the temperature of the vessels and their contents may originally have been quite identical. It has been considered as proof of the different nature of ordinary and thermal heat, that in Gastein, where the springs used for bathing have a temperature varying from 97° to 118° F., it is necessary that such water as is to be used in the morning, should be let in the bathing tubs the evening before, so that it may cool sufficiently. This seems, at first sight, extraordinary; but we must cease to wonder at it, when we reflect that the water there is surrounded by very bad conductors, and that a large quantity of water enclosed in a stone bath, can give off very little caloric; especially as water of the above temperature is constantly in the bathrooms during the whole season, so that the heat of the water can only be very slowly lost.

Liquids lose their heat more or less rapidly according as the conductors remain stationary or not. Air,

of itself, is a very bad conductor of heat; but as it is in perpetual motion, its power of conduction is thereby increased, the heated strata being continually carried upwards and succeeded by such as are colder. If this movement is increased by other accidental disturbances of equilibrium, the cooling of the liquid will be still further accelerated.

Another influence which operates upon the temperature of liquids, is radiation, to which all bodies are subject. The power of radiation greatly depends upon the colour of the liquid, the vessel, and its surroundings. It is greater in dark bodies them in light ones; it is also greater in proportion to the extent of the surface; uneven surfaces radiate more than smooth, and thin bodies more than thick ones. Radiation is also increased by the ascending current which continually pervades a liquid while cooling. In some mineral waters radiation is prevented to a great extent by a pellicle of baregine, which covers their surface. We must further take into account the influence of evaporation, which is very different according to the extent of surface exposed, and the direction in which the vapours are carried off.

Such are a few of the difficulties which beset the experimenter who wishes to compare the cooling of *identical* liquids; there being in that case no difference according to their nature, at a certain degree of temperature. The specific heat is the same in identical liquids, but different in all *different* bodies; and water is cooled differently according to the quality and quan-

tity of solid and gaseous ingredients it contains. It is therefore not to be expected that mineral waters should cool in the same manner as ordinary water. The cooling of water is considerably retarded, if it contains salines in solution, as by this the evaporation is diminished, the boiling point becomes higher, and the freezing point lower. On the other hand, saltwater is a better conductor of heat than ordinary water, and thus the relations become very complicated.

It has also been adduced as a proof for the peculiarity of heat inherent to certain thermal waters, that their boiling point was lower than that of ordinary water. Thus the water of Gastein boils not at 212°, but at 207°.5. But as Gastein is situated 3000 feet above the level of the sea, it is only natural, that water should there boil at a lower temperature than it does in the plain, as the boiling point always becomes lower in proportion to the diminution of atmospheric pressure. Von Graefe has shown, that the boiling point of water taken from an ordinary spring at Gastein, and that of the thermal water, was exactly the same; and that some Gastein water which he had brought to Abano, in Lombardy, situated 40 feet above the level of the Adriatic, boiled there at 212°. From all this it must be evident, that we are justified in entirely rejecting the experiments by Dr Ritter, Scheitlin, and others, which were made without due regard to the circumstances alluded to; and which were thought to prove, that thermal heat had a character of its own; while other experiments leave no doubt as to the non-

existence of any fundamental difference between the two kinds of heat.

In conclusion, a few words may be said on the relation of the temperature of mineral waters to their specific gravity, as this is also a subject upon which most erroneous theories have been brought forward. The specific gravity of a water depends partly upon the solid ingredients contained in it, and partly upon its temperature. For this reason, distilled water has a smaller specific gravity than water containing salines, provided both are of the same temperature. But as the density of water is greatest at 39°, and as it expands above or below that degree of temperature, its specific gravity must become diminished in proportion as it becomes hotter or colder; and it may therefore happen that a thermal water, which contains a small amount of salines at a comparatively high temperature, may have a smaller specific gravity than distilled water of a lower temperature. This is actually the case with the waters of Gastein, the specific gravity of which varies from 0.990 to 0.985, and with the waters of Nocera, in the Papal dominions, in which it is 0.996; that of distilled water at 32° being assumed = 1. M. Streintz has used this apparently extraordinary circumstance for attributing to thermal waters a character peculiar to themselves, and which was entirely different from ordinary water*. It must, however, be evident from the foregoing that this conclusion is

* Les bains de Gastein p. 45.

by no means justified by the facts of the case. If one cubic centimètre of water weighs one gramme at 32°, it weighs 0.999 at 50°, 0.998 at 68°; and only 0.995 at 86°. It is, therefore, not surprising that the water of Gastein, the temperature of which, in the different springs, varies from 118° to 95°, should have a specific gravity varying from 0.990 to 0.985. On the contrary, this is what would be naturally expected, and would be the case with any other water of the same temperature; and it therefore furnishes no reason whatever for assuming the specific gravity of thermal waters to be ruled by laws differing from those which obtain for ordinary and distilled water.

II. COLOUR.

The whitish appearance of certain mineral springs is due to precipitates of carbonates of lime and magnesia. They look bluish, milky or yellow, if sulphur; reddish, if iron; and greenish, if sulphurets are deposited.

III. REFRACTION OF LIGHT.

Water has the power of deflecting and refracting light. This power varies according as we employ air, carbonic acid, glass, or the vacuum, as media; and also according to the temperature and chemical composition of the water. The brine of Rehme, in Westphalia, refracts the light in a powerful manner, and M. Vauque-

lin observed a substance in the water of Vichy, which refracted the green and deflected the purple ray.

IV. ELECTRICITY.

Water containing salines is a better conductor of electricity than ordinary water, and warm water is a better conductor than cold. It is, therefore, not surprising that such Spas as possess a high temperature, and also contain a certain amount of solid ingredients, should offer less resistance to the passage of an electric current than the water of common springs, or distilled water.

Professor Kastner has found, that the electric tension and conduction of the thermal springs of Schlangenbad varied from 13 to 15, that of distilled water being 10. It is easy to understand why the numbers should be higher for the Spa than for distilled water, as the former holds five to six grains of salines in solution. According to Keller and Baumgartner, the mineral water of Gastein exerts a more powerful and uniform influence upon the magnetised needle of a multiplier than common distilled or ordinary water of the same temperature; and Professors Alexander and Desberger have stated that, if electric shocks were administered to persons through the medium of Gastein water, the shocks were much more distinctly felt than if distilled water was used. The springs of Gastein contain 2.75 grains of salines in sixteen ounces of water; and it is, therefore, only natural that they should conduct electri

city better than distilled water. Regarding the supposed difference between ordinary and Gastein water, no proofs have been adduced to show, that the electric current which passed through the water, was always of the same intensity; nor that the two kinds of water used had exactly the same chemical composition and temperature.

The electrical properties of thermal waters have been used for constructing fantastical theories of the action of these springs; but the electrical phenomena which are observed in them, are merely due to thermo-electricity, and may just as well be produced in our laboratories. A transition of water into steam is always accompanied with a development of free electricity; the steam, on being formed, becomes negative, and if it is condensed to water, this is rendered positive. It is impossible to conceive how this should have any physiological or therapeutical action, especially as the phenomena just mentioned are so feeble that they can only be rendered perceptible by means of a sensitive multiplier; and we may, therefore, reject all theories which have been proposed in order to explain the curative powers of the Spas by the exceptional kind of one or all of their physical properties.

CHAPTER III.

THE CHEMICAL COMPOSITION OF THE MINERAL WATERS.

The chemical composition of the Spas is a subject of the greatest importance, in a theoretical as well as in a practical point of view. We can no more hope to unravel the intimate nature, and to understand the curative powers, of mineral waters without a knowledge of their chemical properties, than we could comprehend the nature of disease, or the action of medicines in the system, without being thoroughly acquainted with the anatomy of the human body. I shall, therefore, discuss the chemistry of the Spas as fully and comprehensively as possible.

The specific gravity of mineral waters is greater than that of meteoric water of the same temperature. This fact leads to the conclusion, that Spas contain certain foreign substances, which they must have gathered in their passage through the different strata of the soil. Before reaching the ground, the meteoric water contains only an exceedingly minute quantity of saline and earthy substances, and may indeed be said to be almost chemically pure. Water has a powerful mechanical as well as chemical action upon stone. When precipitated as rain, dew, or snow, it has the immediate effect of diminishing the cohesion, and loosen-

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ing the texture of the rocks; and when it is changed to ice, its mechanical action is increased to the utmost, as it then considerably expands, acts like a wedge, and bursts the rocks asunder. A larger surface is thus offered to the action of the water which afterwards comes in contact with them. Many minerals which enter largely into the composition of rocks, such as sulphates and chlorides, are dissolved by pure water. But it is not to the action of this alone that the rocks are continually exposed; for meteoric water, on being precipitated, absorbs oxygen from the atmosphere; so that substances which would not be affected by pure water, may become oxidised and thus rendered soluble. Oxygen transforms sulphurets into sulphates, and sulphuretted hydrogen into sulphurous and sulphuric acid. Meteoric water, moreover, absorbs carbonic acid, not only from the atmosphere, but also from the decaying vegetable mould through which it passes in its way downwards; and thereby acquires fresh dissolving and decomposing powers, which no rocks, however compact, can resist. Not only coarse-grained stones, but also quartz, basalt, and granite are decomposed by carbonated water. A proof for this is the presence of carbonates in these rocks, carbonic acid not being an original constituent of them. If, therefore, by adding a few drops of sulphuric or hydrochloric acid to such stones, effervescence is produced, we may at once conclude, that they have not withstood the action of the carbonated water precipitated on their surface. M. Struve has shown, that carbonated water, by driving

out siliceous acid, decomposes silicates, under a very moderate pressure. He effected a decomposition of silicates of soda and potash by treating Bohemian basalt, phonolite, felspar from the granite of Carlsbad, and other rocks, with carbonated water. Iron and lime are insoluble as carbonates, but soluble as bicarbonates, so that water may take them up, if it contains a sufficient quantity of carbonic acid. The saline substances thus gathered by the water, enable it to effect further decomposition of the rocks. If, for instance, water which contains sulphate of lime, encounters carbonate of magnesia, the carbonic acid immediately combines with the lime, and the sulphuric acid with the magnesia, so that soluble sulphate of magnesia is formed. Thus water may, by the simple processes of lixiviation and decomposition, become impregnated with a large amount of many foreign ingredients.

Temperature does not, in the majority of cases, exercise a very remarkable influence upon the quantity of salines contained in mineral waters. There are hot springs which are nearly as pure as rain water; such are the spas of Wildbad (96°), Pfäffers (98°), Warmbrunn (104°), Gastein (111°), and Plombières (149°). In other thermals, only minute quantities of gypsum are found, as in the Spas of Pisa (113°), Bagnères de Bigorre (122°), Leuk (125°) and Lucca (129°). The Euganean thermal springs, amongst which those of Abano rank first, have a temperature of about 158°, and contain only a few grains of solid constituents in the pound. Large quantities of alkali are found in

cold as well as in hot springs, such as Fachingen (50°), Bilin (53°), Geilnau (50°), the Fontaine des Célestins at Vichy (67°), Salzbrunn (48°), Schlangenbad (87°), Grande Grille at Vichy (108°), Teplitz (120°), Ems (133°) and Aigues Chaudes (187°). There are, however, a few substances the solubility of which varies with the temperature of the water. Thus silicic acid is only soluble in hot water, and is deposited as soon as this cools, independently of evaporation. Gypsum is most soluble in water at a temperature of 111°, and if a saturated solution of it at this degree of heat is either cooled or heated, gypsum is precipitated. A few other instances of this kind, and the influence of temperature upon the gases contained in mineral waters, will be mentioned hereafter.

Hydrostatic pressure in itself does not exercise any influence upon the greater or lesser quantity of salines in mineral waters; but as, where there is a considerable pressure, the temperature is also high, and large quantities of carbonic acid are often present, the solubility of minerals is, under such circumstances, generally increased.

The specific gravity of water is augmented, after it has dissolved gases and minerals; and its amount depends upon the quantity and specific gravity of these foreign substances, and upon the temperature of the water itself. If salines are dissolved, cold is produced, and the density of the water increased, so that its specific gravity is rendered higher than that of pure water and of the salines added together.

That mineral waters derive their foreign ingredients from the soil through which they flow, was recognissed by the ancients. Thus Aristotle says in his "Meteorologica", that water, which had originally been pure and sweet, was, by passing belowground through limestone, alumina, and other substances, changed into mineral water; and Pliny has an oft-repeated saying: "tales sunt aquae quales sunt terrae per quas fluunt." The merit of having proved this supposition to be correct, belongs to Berzelius, Struve and Bischof, who have, after a most laborious and persevering investigation of this subject, come to the following conclusions: —

We never find in mineral waters ingredients which do not exist in the rocky strata through which the springs flow. The quantity of minerals contained in the springs is proportionate to the amount which is encountered in the rocks, and to their solubility. No ingredients are ever discovered in mineral waters which are not capable of solution or decomposition by water, oxygen, carbonic acid, and alkalies. Minerals which are found everywhere, as for instance chloride of sodium, are contained in almost all springs, while such as exist only in peculiar formations, such as lithia, caesia and rubidia, are confined to the springs flowing through such formations. Minerals which are easily dissolved, such as sulphates and chlorides, are found in large quantities in the Spas, while those which are dissolved with difficulty, such as certain carbonates, are much less abundant. Traces are also found in mineral waters of even those constituents, of which only exceed-

ingly minute quantities are contained in the rocks. If springs contain only a small amount of fixed constituents, this is a sign that the rocks, with which the water comes in contact, are very dense, and not easily soluble.

The most positive proof for the correctness of these views is, that M. Struve succeeded in producing artificial mineral waters, closely resembling the natural ones, by subjecting powdered stone taken from where the springs rise, to the action of carbonated water, under a certain hydrostatic pressure. The following is the composition of the natural mineral spring of Bilin, and of an imitation made by him from clinkstone of Bilin, under a pressure of two atmospheres:

	NATURAL MINERAL WATER.	ARTIFICIAL MINERAL WATER.
Carbonate of soda . . .	22.7 grains.	21.9 grains.
Chloride of sodium . .	2.8 „	1.9 „
Sulphate of potash . .	1.7 „	1.6 „
Sulphate of soda . . .	6.1 „	4.8 „
Silica	0.3 „	0.5 „
Carbonate of lime . . .	3 „	4.4 „
Carbonate of magnesia .	1.1 „	1.1 „
	37.7 grains.	36.2 grains.

The quantity of foreign substances contained in mineral waters, is, on the whole, subjected to little variation. The analyses which have been made of the springs of Carlsbad, Ems, Bath, Bourbonne-les-Bains, Wiesbaden, and many others, have generally shown the same quantity of foreign substances; while in a

few others, as for instance those of Kissingen, Spa, Kreuznach, and Marienbad, considerable variations have been observed. The most remarkable differences have, however, been found to exist in the contents of the springs of Saxon, in the canton of Valais, in Switzerland. M. Morin who analysed them in 1844, did not then find any iodine in the water; in 1852, however, Baron Cesati and Dr. Pignaut, discovered a considerable amount of iodine as well as of bromine in it. Since that time numerous other analyses have been made, which have shown, that sometimes large, and sometimes small, quantities of these substances are contained in the spring, while at other times they are even entirely wanting. Changes of this kind take place in it not only at long intervals, but even within a few minutes, and apparently without any regularity whatever. Thus, on the same day, the amount of iodine found was at one time 0, at another time 0.17, and at another 0.31 in 10,000 parts of water; on another day it was at four different times 0.61, 0.57, 0.17, and 0; on a third day 0.98, 0.47, 0.67 and 0. The largest amount ever found in it was 2.25 in 10,000 parts. When the quantity of iodine contained in the water is considerable, bromine is also present; but if no or only little iodine is found, bromine is entirely wanting. The amount of chlorine contained in the water is not subject to variations on the same day, but only changes in the course of years. Oxide of iron is sometimes found in it, and sometimes not. A few years ago, the same spring contained a large quantity of carbonic acid

and nitrogen; but according to the most recent analysis, no such gases exist in it at present. Where inexhaustible stores of solid matter are exposed to the action of the water, and this always contains the same gases, and remains in contact with the rocks for the same time, no change is likely to take place; but if these and other circumstances are altered, the constituents of mineral waters will vary accordingly. In hot and dry weather the springs become concentrated, while in wet seasons they are diluted. It sometimes happens, that chemical processes take place in mineral springs, by which their own subterranean channels are blocked up. If the water contains sulphates together with iron and organic substances, iron-pyrites is formed. If two mineral springs meet in a cleft, one of which contains carbonate of protoxide of iron, and the other a sulphate and organic matter; or if springs containing earthy salts mix with others, in which alkaline carbonates are present; or finally, if waters rich in silica encounter others carrying organic substances; in all these cases the formation of stony concrements is inevitable. Bischof has also pointed out the fact, that ferruginous waters act as a cement upon sand and similar loose materials, with the same result as above. Under such circumstances, of course, the peculiar composition of the mineral waters becomes much altered.

Great changes in the composition of Spas may also be brought about by earthquakes. After such convulsions, springs which had before been clear and inodorous, have been known to grow turbid and to emit a

disagreeable smell; and for this reason: new fissures were produced, and fresh outlets thus provided for gases, which had been shut in before. On the other hand, fissures which previously existed, may, by earthquakes, become obstructed, and the quantity of gases in a mineral water thus become diminished. During the earthquake of Lisbon the water of Teplitz assumed a reddish-yellow appearance, which lasted for an hour and a half; at the same time the springs of Clifton, in Gloucestershire, became turbid; and on a similar occurrence in 1690, the water of Gastein became white and clayey. The freshwater well of Castle Alfieri, in Piedmont, became charged with salines and sulphurous vapours in 1765, and remained so until 1808, when a fresh earthquake rendered the water again fit for drinking.

Many mineral waters change the aspect of the surrounding surface in a remarkable manner, by depositing as soon as they emerge, fixed matter which was kept in solution during their subterranean journey. These deposits are due partly to cooling and evaporation of the water, and partly to an escape of carbonic acid from it, and other chemical changes. Crystals of sulphur are deposited by sulphurous springs; stalactites are formed by the infiltration of calcariferous water in caverns, which are very frequent in limestone districts; large siliceous deposits are produced by the Geysers, in Iceland, partly in consequence of cooling, and partly by evaporation; one tenth of the silicic acid being precipitated by cooling alone. Similar phe-

nomena may be observed in the valley of Furnao, in the island of St. Michael, one of the Azores, and in the interior of New Zealand. The springs of Starley Bunn, near Edinburgh, and those of Knaresborough, in Yorkshire, cover the rocky hills over which they flow, with thick incrustations of chalk. At Canstatt, in Würtemberg, fifty springs containing a large quantity of bicarbonate of lime issue at a temperature of 60° to 70°; they yield 800,000 cubic feet of water in twenty-four hours, from which a mass of stone weighing 200,000 pounds is annually deposited, and forms an extensive layer of calcareous tufa. The springs in the neighbourhood of the lake of Laach, deposit immense quantities of iron ochre. Near Göttingen, the deposits of lime by springs are so considerable, that it is necessary to clear out from time to time the mill channels through which such springs pass. The Kesselbrunnen, at Ems, deposits peroxide of iron, silica, oxides of copper and lead, and other substances. We find deposits at Nüremberg, which consist entirely of oxide of manganese; at Aix-la-Chapelle such of sulphuret of iron; at Driburg such of gypsum, hydrated peroxide of iron, and protocarbonate of iron, with some peroxide of manganese. In Carlsbad there are large beds of so-called sprudel-stone, which consist of silica, iron, strontia, lime, phosphates of lime and alumina, and fluoride of calcium, which are deposited after the escape of the carbonic acid, independently of the evaporation of water. The brine-spring at Salzkotten is surrounded by a hill of ferruginous limesinter, which has been deposited from the

brine, and the extent of which bears witness to the great antiquity of the spring. The water of Caesar's bath, at Mont d'or, in the Auvergne, forms a deposit of hydrated peroxide of iron, persilicate of iron, and basic perphosphate of iron. In St. Allyre, in France, a calcariferous spring has built a wall four feet broad and three feet high, which is called the Pont natif de St. Allyre. Deposits of sulphuret of iron occur at Chaudes Aigues, in Cantal. In Italy very remarkable beds of sinter are deposited by the numerous mineral springs, which issue from the Appennines. The springs of S. Filippo, on Mount Amiata, in Tuscany, have formed an entire hill of pure, snow-white calcareous matter, and the water which flows down from it, is used there for making basreliefs. The immense travertino quarries of the Ponte Lucano, between Rome and Tivoli, are the remains of a sheet of calcariferous water which formerly existed there, and have been used by the Romans for the erection of their principal buildings. Small carvings, such as crucifixes, and other objects which are exposed to the spray of the cascades of Teverone and Tivoli, soon become covered with glittering grains of calcareous tufa. The sulphuretted spring solfatara, near Tivoli, is also famous in this respect; and a spring which emerges from the foot of Mount Pincio, near the Porta del Popolo, at Rome likewise deposits tufa. The incrustating waters of Thermopylae, in Greece, cover twigs, leaves and even whole trees, with lime, and form islands in the sea; and the Herculean springs of Aedepsos, in Euboea, form cav-

erns full of large stalactites. The thermal springs of Hierapolis, in Asia minor, the composition of which is very similar to those of Carlsbad, have produced a large cliff which looks like an immense frozen cascade, and upon which the ancient city of Hierapolis, or Pambouk, opposite Laodicea, was situated. Strabo and Pausanias relate, that when the water was conducted about the vineyards and gardens, the channels became long fences, each of which looked as if formed out of a single stone. Between Erzeroum and Trebisonde a warm spring of a similar character issues from limestone rocks, and has built a wide arched bridge of tufa and stalactites across a river; a similar bridge is now in course of formation further down the same river.

In Africa, the most renowned springs of this kind are those of Mescutin, between Bona and Constantine, which contain a very large amount of bicarbonate of lime. Close to their course are many greyish-white columns, from three to twenty feet high, which have the form of sugar loaves and consist of lime-sinter deposited from the water. The Arabs relate, that an incestuous wedding was once held at this place, and that these cones are the guests petrified on the occasion by the anger of God; hence the springs are called Mescutin (charmed). A rivulet, at a distance of several hundred yards from this place, has still a temperature of 167°, and incrustates on its way all plants and other objects over which it flows. Such phenomena go far to explain numerous old traditions of rivers, which

build natural bridges, and were said to have petrified whole towns and their inhabitants.

Deposits of this kind are abundant in proportion to the multitude of plants and other objects which the springs meet in their course. Plants offer a large surface to the water, and thus promote evaporation; and infusoria appropriate to themselves certain ingredients of the mineral waters, such as silica, iron, lime, and arsenic, from which they form their coat or skeleton; just as corals extract lime from the sea-water, with which to build their reefs. At the same time mineral springs, especially sulphurous thermals, favour the development of microscopic vegetable organisms, and the formation of barègine.

Considerable changes in the interior of the earth are likewise brought about by mineral waters. Acting both mechanically and chemically, they form subterranean excavations, and may give rise to landslips. Solid parts are abstracted from the ground, silicates are changed into carbonates, and crystalline rocks rendered loose and friable. By oxidation sulphuretted hydrogen is changed into sulphurous and sulphuric acid, and where the latter encounters carbonate of lime, gypsum is formed. The Sprudel, of Carlsbad, furnishes about 1500 bucketsful of water in the hour, and brings up twenty million pounds of sulphate of soda, and thirteen million pounds of carbonate of soda annually. The rivers of the Teutoburger Wald remove from the mountains a quantity of carbonate of lime, which would be equivalent to a cube of a hundred feet lateral di-

mensions. This constant drain from the interior shows, on the whole, no sensible diminution, and the absolute amount of fixed matter thus withdrawn, is, after all, not so very large, when we consider the inexhaustible masses which exist in the earth. Vetter has calculated that, if the Royal Castle at Berlin consisted entirely of carbonate and sulphate of soda, it would furnish sufficient matter for supplying the Carlsbad Sprudel for a hundred years; and Struve has endeavoured to show, that the salt-mines of Wieliczka, near Cracow, might supply it for 50,313 years. It must, however, not be supposed, that the salines brought up by the mineral springs exist in the soil in a pure condition; on the contrary, they are merely extracted from rocks, and the actual quantity of fixed constituents contained in a Spa, implies the presence of an infinitely larger amount of solid matter in the soil. In an experiment performed by Struve, out of sixty ounces of clinkstone of Bilin, which were finely powdered and subjected to the action of 45½ ounces of carbonated water, only forty-eight grains of solid matter were actually dissolved, so that one pound of mineral seems to be necessary for supplying ten grains of solid constituents to a Spa.

The method of analysing mineral waters is not different from that used for any other fluid containing fixed matter in solution. For a minute qualitative analysis of such waters, the spectral method recently proposed by Messrs Kirchhoff and Bunsen is admirably adapted. This is a means of research, which has con-

siderably enlarged the domain of chemical investigations, and has rendered possible the solution of problems which were hitherto believed to be unapproachable*. It is well known that many substances, when introduced into a flame, have the property of imparting to the spectrum of the flame peculiar and brilliant rays, which are especially striking, when the heat of the flame is very great, and its light insignificant. By means of this method, Professor Bunsen has found that lithia which was formerly believed to be extremely rare, is indeed most universally encountered in nature; and he also discovered in the mineral springs of Dürckheim two new metals, to which he has given the names of caesium and rubidium, which are closely related to potassium, and are the most electro-positive substances known. The apparatus used for such researches consists of a box blackened inside, and in which two small telescopes are fixed. The ocular of one of these is replaced by a disc of brass, furnished with a vertical slit, which is placed in the focus of the object-glass. A lamp is placed before this slit in such a manner, as to make the axis of the glasses correspond with the mantle of the flame. A little below this point, a very fine platinum wire is fixed, which is bent in the form of a hook. In this a small piece of the substance to be examined is placed. Between the object glasses of the two systems, a prism of 60° is fixed, supported by a

* Analyse chimique fondée sur les observations du spectre. Par MM. Kirchhoff et Bunsen. Annales de Chimie et de Physique. Paris, August 1861 p. 452.

disc of brass, which can be moved round a vertical axis. This latter carries a mirror, which, together with a prism, may be turned by means of an arm; and before the mirror a telescope is placed, from which the divisions of a horizontal scale, placed at a certain distance, may be read off. The divisions of this scale correspond to the portions of the spectrum. If sodium, or a compound of it, is placed in the platinum hook, a yellow ray of extraordinary brilliancy is produced. Lithium causes a red ray; potassium one red, and another violet; strontium gives six red rays, one orange, and one blue; calcium one orange, and another green; and baryta two intense yellow rays. Extremely minute quantities of these substances are quite sufficient to produce these rays. If a drop of the mineral water of Dürckheim, or Kreuznach, is introduced into the flame, a little spoon being used instead of the hook, we may at once distinguish the yellow ray of sodium, the red ray of lithium, and the orange and green of calcium. If the mother-lye of these waters is examined, the same rays appear with a far greater brilliancy, and continue for a long time. After the chloride of sodium and lithium have been volatilised, and the chloride of calcium has become more basic, the rays of strontium appear, at first feebly, but soon with great intensity. A drop of sea-water, which is evaporated on a platinum plate, gives a strong reaction of sodium; after the tablesalt has become volatilised, a feeble reaction of calcium appears, which may be immediately intensified by moistening the residuum with some hy-

drochloric acid. If sulphuric acid, and then alkalies, are added, the characteristic rays of potassium and lithium are observed. The presence of strontia in sea-water is best demonstrated by operating upon the incrustations found on the boilers of steamships. For showing the presence of alkaline and earthy substances, spectral analysis is, in fact, more certain and rapid than any other method; as it is easy to at once distinguish, from the colour, the position, intensity and brilliancy of the rays, the nature of the substances by which they are produced. The rays thus generated are analogous to the precipitates obtained in ordinary chemical analysis, although they are far more characteristic than these latter. As precipitates may present a gelatinous, pulverised, curdy, grained or crystalline appearance, thus the spectral rays differ according to the diffusion or nicety, and the greater or less extent, of their contours. Most of the precipitates, however, are white, a few only being coloured; and if there is coloration, this is not permanent, but generally assumes varied shades and tints, according as the deposit is more or less finely divided. A very small quantity of foreign substances is often sufficient for altering the colour of the precipitates, while, on the contrary, the spectral rays are not subject to any such changes, their purity being unaffected by the presence of other matters. The colour of the spectral rays, therefore, constitutes a chemical property of matter which is of the first importance, as they are as unchangeable as the atomic weight itself; and it may, therefore, serve to determine the

nature of bodies with almost absolute certainty. Where the metallic compounds are too fixed to show their nature, when merely introduced into the flame, the electric spark may reveal it by its colour, if the discharge takes place between electrodes formed of such substances; especially if large sparks are employed. With the use of Ruhmkorff's coil, therefore, this method of investigation may be applied to all metals which exist, even to erbium, terbium, yttrium, nickel, cobalt, silicium and others.

The minerals are contained in the Spas as salts; chemical analysis, however, merely shows the elements, the acids and the bases, which are present in the water, but not the mode of their combination. It has, therefore, often happened that, if several chemists have analysed the same spring and found the same ingredients, the tabular views of the contents given by them, have nevertheless been different, as they adopted different modes of combination. Generally speaking, however, the principle should be acted upon, that the strongest acid is to be combined with the strongest base, and that salts which are with difficulty soluble, are formed in preference to those which are easily soluble. The affinity of the several bases to sulphuric acid is as follows: baryta, strontia, potash, soda, lime, ammonia, magnesia; for nitric and hydrochloric acid, however, potash and soda rank first, and are followed by baryta, strontia, and lime. In some instances it seems to be impossible to accurately determine, whether a

certain acid is combined with potash or soda, with ammonia or magnesia.

The *water* in which the minerals are dissolved, is in no way different from ordinary water. This remark might seem superfluous, but it is not so in reality. Messrs Baumgartner and Hessler have, indeed, stated, that the water of Gastein was composed of one part of oxygen and *three* parts of hydrogen; and a law enacted in the duchy of Salzburg, in 1797, threatens all persons, who should so far forget themselves as to call the Spa water, with a penalty of 24 pence. This law has not yet been repealed, but the assertion of Messrs Baumgartner and Hessler has been shown, by numerous subsequent analyses, to be without any foundation whatever.

I now proceed to consider in detail the relations of the gaseous and solid ingredients which are found in the mineral waters.

1. CARBONIC ACID.

One of the most important and interesting constituents of mineral waters is carbonic acid, the "spirit of the springs", which not only greatly contributes to the solubility of certain salts contained in such waters, but also renders them more palatable and more agreeable to the stomach. It is especially important for chalybeate waters which, when devoid of carbonic acid, soon lose the iron which was in solution, and also become heavy and unpalatable. There are some very

strong chalybeates in England, as for instance the springs of Sandrock, in the Isle of Wight, those of Dorton, in Oxfordshire, and those of Tunbridge, which, if they only contained carbonic acid in sufficient quantity, would no doubt attract a large number of patients from this and other countries, who now resort to the waters of Spa, Driburg, Schwalbach, Pyrmont, and other continental places. The strongest chalybeate known in the whole world, is the Acqua ferrata di Rio, in the island of Elba; but as it does not contain any carbonic acid, it is entirely useless for medical purposes.

In mineral waters, carbonic acid is found in three different states. It is either "*bound*" to certain bases, with which it forms carbonates; from these the gas does not escape, when the water is heated; or it is "*half-bound*", forming sesquicarbonates and bicarbonates, from which compounds, part of the gas is disengaged as soon as the water comes in contact with the air, and still more rapidly, when it is heated; so that, since certain salts are only soluble as bicarbonates, and insoluble as carbonates, they are precipitated as soon as the surplus atoms of carbonic acid are gone; finally it is contained in the waters *free*, as gas, which escapes at the ordinary temperature, as soon as the water rises out of the earth, and the pressure, under which it was in the interior, ceases. This escape is more rapid and powerful, when the water is hot or artificially heated. Carbonic acid is found almost entirely pure in the neighbourhood of the lake of Laach, in Meinberg, and

Driburg, while in other places it is found mixed with nitrogen, sulphuretted hydrogen, and oxygen.

The tension with which the gas escapes, shows considerable variations in the several mineral waters. In those localities where it has many outlets, the tension is, generally speaking, inconsiderable; but if borings are made in places where there has been no previous exit of gas, the pressure is sometimes so powerful that, as soon as an opening is made, it rises twenty or thirty feet into the air, carrying with it large stones from the boring hole. This has often been observed in boring for artesian wells. The same is the case if the escape of gas is accidentally or intentionally impeded. Thus, some time ago, the tube connected with the acidulous spring at Pyrmont, had become obstructed, whereupon the gas heaved up not only the large metal funnel, which, at its upper end, is eight feet in diameter, but also the whole cottage that had been built over it.

The quantity of carbonic acid contained in the Spas, is very variable. It is well known, that common spring-water contains a certain amount of carbonic acid (from one sixth to one fourth of a cubic inch in the pound). River water is also slightly impregnated with this gas, and a little more of it is found in sea-water than in fresh water. The small quantity contained in drinking water is sufficient to impart to it a refreshing taste, which no water has that is quite devoid of carbonic acid. But the amount of this gas contained in springs, rivers and the sea, is very trifling, when compared with the quantity found in certain Spas. It varies from one to sev-

enty cubic inches in the pound, and such waters as contain ten cubic inches or more, are called acidulous springs.

The amount of carbonic acid found in mineral waters is dependent upon several conditions, of which the chief are, hydrostatic pressure, and temperature. According to Lersch, one ounce of water at a temperature of from about 40° to 60° F., absorbs, at the ordinary pressure of air, one grain of carbonic acid. If the pressure increases, more gas is absorbed, but not in the same ratio; as by a pressure equal to seven atmospheres, not seven, but only five, times the ordinary amount of gas is dissolved. As soon as this pressure ceases, gas-bubbles are set free from the mineral spring, in the same way as on opening a bottle of Champagne.

The escape of carbonic acid from the springs, is considerably influenced by the variations of atmospheric pressure. When the barometer rises, less gas is set free; but if it falls, as, for instance, before a storm, the amount of gas evolved is very large; the bubbles rise more rapidly, the surface of the springs appears more agitated than usual, the water has a more refreshing taste, and where baths of this gas are given, the bathers find it impossible to bear the powerful effects of it; a circumstance which has been more especially noticed by M. Bertrand in the gas-baths of the Auvergne. The carbonic acid discharged by the Racoczi of Kissingen, varies, according to the atmospheric pressure, from 110 to 170 cubic inches of gas in a minute. These gas springs may, therefore, serve as indicators of an

impending change of the weather, and only seldom deceive the observer. In consequence of a diminished amount of gas kept in solution by some springs, oxide of iron, which is only soluble if a sufficient amount of carbonic acid is present, is precipitated, and imparts to the water a red colour, which mostly indicates the approach of heavy rains. It is from such and similar natural phenomena that weather-wise persons draw their prophecies.

The *temperature* of the water has also an important bearing upon the amount of carbonic acid contained in it. The capability of water to absorb carbonic acid, decreases in an inverse proportion to its temperature. Accurate calculations have shown that 1000 volumes of water will, when heated from 40° to boiling point, expand to 1043 volumes, while 1095 volumes of carbonic acid, which are absorbed by 1000 volumes of water, expand to 1417 volumes. If, therefore, acidulous water is heated, the gas expands more largely than the water; and for this reason alone, part of it must escape. But there are other influences at work, which carry off a still larger quantity of gas from heated water, namely the diminution of affinity which exists between hot water and other gases but its own; the more steam there is present in water, the less of foreign gases can be kept in solution. Besides, the steam-bubbles which rise from water when heated, mechanically carry the carbonic acid away with them. At boiling point, carbonic acid is entirely expelled, as are in fact all foreign gases; but gentle heat is not suffi-

cient to drive the gas entirely out. Thus water used for bathing, at a temperature of 86° to 88° F., may still be so much saturated with the gas that, if the patients enter the tubs, the whole surface of the body becomes thickly covered with bubbles of carbonic acid, and if wiped off, they immediately re-appear. A low temperature enables the springs to retain a large quantity of carbonic acid, and, consequently, to keep in solution a comparatively larger quantity of certain substances, which are insoluble in its absence; and if the gas escapes, such substances are at once precipitated.

The more or less intimate connexion of carbonic acid with certain mineral waters, has been the subject of much mystical misrepresentation. Thus it was observed, that the gas is more loosely bound to the acidulous springs of Silesia than to those of Pyrmont, Spa, Selters and Driburg; that the gas seemed only to travel through some of the springs, while others were very firmly impregnated with it; and such and similar observations were adduced to show, that physical laws were not sufficient for explaining the wonderful phenomena connected with the "spirit of the springs." But if we analyse the actual state of things, it is not difficult to account for it in a scientific manner. Thus, for instance, we should naturally expect that the water of Reinerz, in Silesia, would lose its carbonic acid sooner than that of Driburg, in Westphalia, as the former has a temperature of 66°, and the latter of 51° only. But it is true, that temperature and pressure are not, in all cases, sufficient to account for the more or less intimate

connexion of carbonic acid with water; in such instances, however, we can always trace other physical or chemical influences at work. Thus, if water saturated with a certain gas, comes in contact with other gases which it does not yet contain, it will dissolve a certain amount of these latter; but with the loss of a certain quantity of the former. If water, which, when rising from the earth, contains no other gas than carbonic acid, comes in contact with the atmosphere, it at once absorbs nitrogen and oxygen, whereby carbonic acid is driven out; but when water is already impregnated with oxygen and nitrogen before it rises, carbonic acid will be the more firmly bound to it. Finally we have to consider, that water keeps gases less easily in solution, in proportion to the increase of its own specific gravity. Carbonic acid, therefore, escapes more rapidly from strongly concentrated saline waters, than from such as contain only a small quantity of solid ingredients. If these circumstances are borne in mind, we shall almost always be able to explain the relations of carbonic acid to water; and may, in fact, often determine à priori, whether a certain Spa is likely to contain much or little of this gas. Thus, for instance, the brines and bitter-waters, which contain from 80 to 2000 grains of salines in the pound of water, will not contain much carbonic acid; the bitter-water of Friedrichshall, in which 193 grains of salines are dissolved, does not contain any carbonic acid. Thermal springs will also contain very little of it, on account of their high temperature, while such waters as are rather cold and

contain only a moderate quantity of solids, present the most favourable conditions for absorbing a large amount of this gas, and keeping it in solution for a considerable time. In some Spas it is contained in such large quantities, that it constitutes their chief element; while in others carbonic acid is not the characteristic feature of the water, although it essentially modifies the composition and the effects of the same.

The sources from which mineral waters derive carbonic acid, are of various kinds; and where they are abundant, waters which have a high specific gravity and a comparatively high temperature, may contain more gas than others of, perhaps, less gravity and temperature, but wich issue in a neighbourhood where the sources of it are sparing. Small quantities of carbonic acid are absorbed by the springs from the upper strata of the earth, which attract it from the atmosphere, and in which it also accumulates by putrefaction of organic bodies. Fossil remains of plants contain a large amount of carbonaceous matter; and we find in the sedimentary strata an abundant material for the formation of carbonic acid by decay. If water runs through such strata, their substance is decomposed by the oxygen which is present in it; and thus carbonic acid is formed, which is generally mixed with sulphuretted hydrogen, and combustible pit-gas. That free oxygen is lost in this way, and oxygenation of carbon takes place, is evidenced by the circumstance, than common spring-water contains less oxygen than rain-water (respectively 16and 17 volumes of it in 1000 volumes of water).

But the sources of carbonic acid I have just enumerated, only hold good for a limited number of acidulous springs, most of which occur in districts, where there are active or extinct volcanoes or basaltic rocks. Exhalations of carbonic acid, either in its free state as gas or united with water, are, in fact, generally the last remnants of plutonic catastrophes. Carbonic acid can at present only rise where disruptions of the crust of the earth exist, and its upper strata do not offer an impediment to the egress of the gas. Such rents we find, for instance, in Germany, at Pyrmont, where the well-known Grotto of Dogs is filled with pure carbonic acid, and powerfully acidulated chalybeate springs issue from the fissures in perpendicular layers of sandstone. Carbonic acid also rises from the basalt formation which we find extending through Germany from the Eifel to the Riesengebirge. In the neighbourhood of the lake of Laach, in the Eifel, there are more than a thousand acidulous springs close to each other; the circular valley, in which these exhalations occur, being probably the crater of an extinct volcano. In some of these springs, the bubbles which escape from the water are as large as the head of an adult, and force the water upwards to the height of more than a foot; they produce, especially at the eastern shore of the lake, a noise as of hissing, whizzing, and gurgling, which is heard at a considerable distance. Within a few miles of Marienbad, we find 124 acidulous springs, and the quantity of carbonic acid developed in them is something prodigious. From an approximative calculation,

the springs of Meinberg furnish about one million of cubic feet annually, and those of Nauheim eleven millions. The gas spring at Kaiser-Franzensbad yields 2,102,400 cubic feet, and that of Neusalzwerk, in Prussia, 1,576,800; but together with the gas carried away by the water, it amounts to 24,248,976 cubicfeet. The quantity of carbonate of lime, which is every year extracted from the Teutoburger Wald by the Pader, Lippe and other rivers and rivulets, is equal to a cube of more than 100 feet; and for the solution of such a cube of limestone, 779 million pounds of carbonic acid are necessary. In France, there are exhalations of carbonic acid in the cave of Montjoly, in the Auvergne, and the Puits de Nérac, in the Vivarais. In Italy, we find the gas-springs of Sciacca and Latera, at the foot of the Etna; the famous grotto del Cane, near Vesuvias; the lake of Amsanctus, near Naples, in which the carbonic acid is mixed with sulphuretted hydrogen; and the Guada mortale, in the neighbourhood of that lake, which contains pure carbonic acid, and where sheep, hares, and rabbits, are often found suffocated. After every eruption of Vesuvius, temporary exhalations of carbonic acid appear in the neighbourhood of that volcano, the so-called mofettes, which exercise a very destructive influence upon vegetable and animal life, but ultimately disappear entirely. In Greece, there were and are still, many places where escapes of this gas occur. Such was the steaming cave in Apollo's oracle at Delphi, where the Pythia pronounced her prophecies; the gas-springs in the sacred forest of Do-

dona, near Epirus, the most ancient oracle of the Greeks; the springs of Thermopylae, and many others. The phenomena observed in such places are so remarkable, that we cannot be surprised at finding an uneducated age and people looking upon them as manifestations of supernatural powers. In fact, the hissing and gurgling sounds, occasioned by the discharge of the gas, were, by the ancients, believed to be the voices of demons. It was in places like those just mentioned, which were called the *spiracula Orci*, that, according to Homer and Virgil, Odysseus and Aeneas went to the lower world to meet the spirits of the departed; that oracles were founded which were used by a cunning priesthood to deceive the vulgar; and it was into the awful lake of Amsanctus that, according to Virgil, the fury Alecto, in her anger, precipitated herself from the summit of the mountain.

Volcanic agency does not, however, *produce* carbonic acid; it merely provides it with an outlet, tearing asunder the crust of the earth, and taking away the obstruction to the free escape of this gas from the interior of the globe. The most abundant source of carbonic acid is, no doubt, the decomposition of carbonates, such as the carbonate of lime, of iron, of magnesia, which enter into the composition of the solid crust of the earth. Common limestone alone exists in such quantities in it, as to be able to give out inexhaustible streams of carbonic acid from every point of the earth's surface, of which this salt, together with silica, forms the greatest part, its geognostical distri-

bution extending from the newest tertiary deposits to the oldest primitive rocks. From its combination with lime, carbonic acid is evolved partly by sulphuric and hydrochloric acids, which exist in the interior of the earth, sulphate and chloride of lime being thus formed, and partly by a simple process of calcination which is continually carried on at a certain depth in consequence of the heat inherent to the interior. Berzelius believed that the action of the heat, and therefore, a continued evolution of carbonic acid from limestone, ceased at a depth of two or three fathoms from the surface, in consequence of the very bad conducting power of the stone. But Bischof has shown that, if limestone is exposed to a high degree of heat, it cannot retain its cohesion and firmness; in fact, under such circumstances, the rock soon cracks in every direction, is disintegrated into fragments, and thereby affords ample room for the continued influence of the heat, which is, of course, assisted by the presence of a large amount of aqueous vapours. This is, only on a larger scale, the very same process which we may every day observe in our artificial limeworks.

Acidulous springs are always situated at the lower part of mountain declivities, or at the deepest points of valleys; while exhalations of dry carbonic acid gas generally occur at higher places upon the declivities of mountains, although not so high as fresh-water springs, which issue very considerably above the bottom of the valleys. Springs containing a large amount of carbonic acid, are always ascending ones, and originate from

the contact of water driven upwards by hydrostatic pressure, with subterranean exhalations of carbonic acid.

2. SULPHURETTED HYDROGEN, SULPHUROUS ACID, SULPHURIC ACID, AND SULPHURETS.

Amongst the gaseous ingredients of mineral waters, sulphuretted hydrogen ranks next in importance to carbonic acid. It is either exhaled from the soil as gas mixed with steam, or it is absorbed by water, to which it imparts its peculiar taste and smell. Sulphurous exhalations exist chiefly in the neighbourhood of volcanoes, and are probably due to a decomposition of certain sulphurets by hot water, a temperature of 111° being sufficient to set free sulphuretted hydrogen from a solution of sulphuret of calcium. Sulphuretted hydrogen is decomposed if subjected to a still higher temperature, and is therefore not found when volcanic eruptions are at their acme, but only after they have somewhat abated. Thus we do not find it in the smoke emitted by Vesuvius, but in the Solfatara of Puzzuoli. "Solfataras" are half-extinguished volcanic vents, where sulphur is sublimed; and "fumaroles" are visible escapes, from fissures of the earth, of sulphuretted hydrogen, mixed with nitrogen, hydrochloric and carbonic acid, air, and steam. Sulphuretted hydrogen is also found in the water of artesian wells, together with certain other gases. It is never very firmly bound to water, and is easily decomposed if it comes in contact with air, as hydrogen then com-

bines with oxygen, and sulphur is precipitated on the surface of the spring. This may, for instance, be observed in the Kaiserquelle of Aix-la-Chapelle, where the water remains perfectly clear so long as it is shut out from the air; but as soon as it comes in contact with the atmosphere, it assumes a milky and opalising appearance. Part of the sulphur thus sublimed is oxidised, and changed into sulphurous and sulphuric acid. Sir Humphry Davy found such quantities of sulphurous acid in the smoke emitted by Vesuvius, that he was unable to approach its crater. Sulphuric acid is found pure in the Pusambio river, in the Andes of Popayan; in a river on Mount Idjen, on the eastern coast of Java, and in several mineral springs in the island of Elba. Where these acids meet with limestone, gypsum is formed; this is the case in the crater of Vesuvius, and in Teneriffe, in the fumaroles of Tuscany and Lipari, and in the sulphur-baths of Aix in Savoy, where the limestone walls of the saloons and bathing-rooms blister and become covered with crystals of gypsum. This process is much assisted by rain, which conveys the sulphuric acid into the interior of the rocks. Sulphur is also precipitated from the vapours, which ascend from springs. In 1808, the vault above the Kaiserquelle of Aix-la-Chapelle was opened, when beautiful octahedral crystals of pure sulphur were found, which weighed nearly a hundred pounds. Similar deposits are formed at Baden, in Switzerland, at Aix in Savoy, in the volcano Pakkuodjo in Java, by the thermals of Abano, in Lombardy, and by many other mineral waters.

When water containing sulphates comes in contact with organic matter, sulphuretted hydrogen is evolved; and sulphurous springs, therefore, generally issue in the neighbourhood of marshy ground, coal-beds, and bituminous rocks, where organic remains are plentiful. The following decomposition then takes place: Carbon unites with oxygen, to form carbonic acid; and sulphur with metal, to form an alkaline or earthy sulphuret; this latter is then again decomposed by the carbonated water, sulphur combining with hydrogen to form sulphuretted hydrogen, while the metal is oxidised and, with carbonic acid, forms a carbonate. Carbonic acid is, therefore, frequently found together with sulphuretted hydrogen; and as the water which penetrates into the earth, contains air, nitrogen is likewise found in sulphurous exhalations. Sulphurous springs are never met with in unmixed strata, but only in the younger sedimentary formations. In the Pyrenees where they abound, they rise from the boundary between granite and slate or chalk. Lersch has divided the sulphurous springs into three classes, viz. such as contain carbonate of soda, those with sulphate of lime, and finally those containing silicate of lime.

As the presence of sulphates, water, and organic substances, is quite sufficient for the development of sulphuretted hydrogen, we have to distinguish between native and accidental sulphurous waters. If water which contains gypsum, but does not originally contain any sulphurets, comes in contact with morasses or marshes, sulphuretted hydrogen will immediately be

set free. Some time ago it was believed that two new sulphurous springs had come forth at Bagnères de Bigorre; but M. Fontan showed that the sulphuretted hydrogen contained in them was merely due to a great black morass, through which the water flowed; and after this had been cleared out, the springs ceased to be sulphurous.* The waters of Enghien, Bourbonne, and St. Marie, are also mere accidental sulphurous waters. The same may be said of such sulphurous mineral waters, whether natural or artificial, which originally contained sulphates, and have for some time been preserved in bottles. In these any small pieces of organic matter which may have accidentally entered, such as bits of cork or straw, immediately give rise to decomposition, and the formation of sulphuretted hydrogen.

The most concentrated solutions of sulphuretted hydrogen which are to be met with in nature, are the Solfatara lakes, near Rome; but in most of the sulphurous Spas comparatively little of this gas is contained. Water which contains one cubic inch of sulphuretted hydrogen, or 0.42 grains of sulphur, in the pound, is considered a strong sulphurous water. The quantity of sulphur which is found in the Spas of the Pyrenees, varies from 0.012 to 0.46 grains. Weilbach which is considered a strong sulphurous Spa, only contains 0.127 grains of sulphuret of sodium, or 0,052 grains of sulphur; Landeck contains 0.093 grains of earthy sul-

* Recherches sur les eaux minérales des Pyrénées. Paris 1838. p. 93.

phurets, or 0.012 grains of sulphur: Neundorf 0.134 to 0.555 grains of sulphuret of calcium, or 0.072 to 0.298 grains of sulphur, and Aix-la-Chapelle 0.073 sulphuret of sodium, or 0.03 grains of sulphur. For the formation of 0.4 grains of sulphur, only one grain of sulphuric acid, or 1.7 grains of gypsum is necessary, which amount is found in many mineral waters. If the barometer rises, and the cold is intense, sulphurous springs contain more gas than under opposite circumstances. Many sulphurous Spas, such as those of the Pyrenees and others, do not contain any sulphuretted hydrogen, but merely sulphurets.

3. OXYGEN.

According to Bischof, water which is in contact with the atmosphere, absorbs 1.6 parts of oxygen and 3.4 parts of nitrogen. It seems that cold promotes the absorption of oxygen by water; that sea-water contains more of it than fresh-water, and rain-water more than the water of springs; from which latter circumstance it may be inferred, that the oxygen is used up in the interior for the oxidation of certain substances, especially of organic remains. According to Longchamp, oxygen, when under a pressure of fifty to sixty atmospheres, combines with sodium and sulphur, to form sulphate of soda. Very little oxygen is contained in mineral waters, as in most of them it does not amount to more than half a cubic inch in the pound; and in some, as, for instance, those of Aix-la-Chapelle, no oxygen whatever is to be discovered. This is probably

the case with most sulphurous springs, as oxygen cannot remain free when it comes in contact with sulphuretted hydrogen. Giulii, Ferrara, and others, have asserted that a large quantity of oxygen is contained in the saline springs of Ragusa, in Sicily, in some of the Tuscan Spas, in the waters of Plombiéres and Nocera; but these statements require further confirmation before they can be adopted.

4. NITROGEN.

As springs are fed by meteoric water which always contains a certain amount of air, we should expect that no spring could be entirely devoid of nitrogen. There are, however, a few Spas in which no nitrogen whatever has been discovered; and it is possible that it may, in these instances, have combined either with hydrogen or oxygen, to form ammonia or nitric acid. Pure nitrogen is exhaled by the thermal springs of the Pyrenees; azote mixed with a small amount of other gases, is evolved by a few warm springs in Ceylon, and by the Spas of Gastein, Pfäffers, Leuk, Warmbrunn, Landeck, Baden-Baden, Wiesbaden, Aix-la-Chapelle, Borcette, Lippspringe, Subveni Homini near the Posilippo at Naples, Orense, in Spain, and the Geyser in Iceland; also by the cold mineral water of Sebastiansweiler. The nitrogen evolved from springs is either derived from the atmosphere, or from the exhalations of volcanoes, or from azotic organic substances which exist in the sedimentary strata of the earth, and are there decomposed by water.

5. STEAM.

Aqueous vapours rise from the earth either pure or mixed with other gases. They are chiefly exhaled in volcanic regions, and evolutions of steam very often precede volcanic eruptions. Exhalations of steam occur chiefly in Southern Italy, where, when hot enough to induce profuse perspiration, they are called Stufe or sudatorio secco. The Stufa most celebrated for its curative powers, is that of S. Germano, near Naples, which besides steam, contains carbonic acid and sulphuretted hydrogen, and has a temperature of 200°. The vapour rising from the Stufa di Nerone, in the same neighbourhood, consists of pure steam. Another Stufa is that of Pisiarelli, on the Eastern declivity of Monte Secco, near Naples, and which is also called La Bolla, from the bubbling noise produced by the gas. Similar gas-springs are found in the island of Ischia, where the Stufa di Castiglione, and also those of Gurgitelli, S. Lorenzo, Testaccio, Citara and Cacciuto, are much frequented by patients suffering from gout and rheumatism. Many gas-springs of the same kind exist in Sicily and the Lipari Isles, especially in Stromboli, where the Stufa di S. Calogero is most famous. In the lagunes of Tuscany there are numerous rents in the soil (suffioni), from which hot steam containing boracic acid issues at intervals with a loud noise, and from which water is thrown up to a considerable height. The soil in these places is very thin and hot, and gives a hollow sound when trodden on.

6. CARBURETTED AND SUBCARBURETTED HYDROGEN.

These gases are produced by the decomposition of organic bodies below water. They occur either free as gases, or dissolved in mineral springs. Exhalations of them are very frequent in coal-pits, where they proceed partly from the coal itself, and partly from fissures in the adjacent rock. In the peninsula of Abscheron, on the western shores of the Caspian, there in a tract of country known as the field of fire, which continually emits carburetted hydrogen, and which rises there with such violence, that mud and stones are thrown up by it. Springs of naphtha and petroleum also exist in the same neighbourhood. The "eternal fire", near the village of Kinalughi, 7834 feet above the level of the Caspian Sea, consists of exhalations of the same gas, which issues from clefts in sandstone alternating with slate. This burning gas is never extinguished by wind, rain, hail or snow. In the village of Fredonia, near Lake Erie, in the state of New-York, the same gas rises from a bed of rock-salt, under which lies an extensive coal-bed; and is evolved in such abundance, that it is conveyed in pipes to the houses, and used by the inhabitants for lighting and cooking. 84 percent of the gas evolved from the rock-salt of Wieliczka consist of carburetted hydrogen. Of a similar nature are the fire-wells which are found in Tshee-lieou-tsing, in the province of Tse-chuan, in China, where a single source of gas heats three hundred kettles. In Java the fire produced by this gas is green, and in the temple of Jualamuki,

in India, it is red. A short time before storms and scirocco-winds, lights are seen dancing about the ridges and crags of the Acroceraunian Mountains in Greece: and the people there foretell the approach of heavy rains, by the increasing size and fury of the flames which issue from the ground. The celebrated fire of Pietra Mala (Fuochetto), between Bologna and Florence, is also due to carburetted hydrogen: this sometimes rises to a height of several feet, and the flame is reddish at the top, sky-blue below, and yellow in the middle. Carburetted hydrogen is likewise evolved from the springs at Aix-la-Chapelle and Nenndorf, from the Herkulesquelle in the Banate, from that of Niederlangenau, in the county of Glatz, and from the Adelheidsquelle, at Heilbronn, in Bavaria. Pliny relates of the fountain of Jupiter, at Dodona, that although it was as cold as ice, and extinguished torches plunged into it, it rekindled them if they were approached to the surface of the water. This may possibly have been owing to the presence in it of carburetted hydrogen.

7. CARBONATES AND BICARBONATES.

Many mineral waters are rich in alkaline carbonates; and there are scarcely any springs, which do not contain at least traces of them. Alkaline carbonates are formed when carbonated water remains for a sufficient time in contact with rocks containing alkaline silicates, such as basalt, granite, syenite, &c. This change of silicates into carbonates is a slow pro-

cess, while, on the other hand, the circulation of the water is, generally speaking, very rapid, so that a certain quantity of carbonated water only acts for a short time upon the stone. Bischof has calculated that for the saturation of water with bicarbonate of soda thus produced, the water must remain in contact with the rocks for a whole year; from which it results that such saturation will scarcely ever take place. As the change of silicates into carbonates is favoured by a high temperature and great hydrostatic pressure, this decomposition take place more easily in the interior of the earth than on its surface.

Carbonate of soda is found in numerous springs in Bohemia, in the Riesengebirge, the Taunus Mountains, in the neighbourhood of the lake of Laach, and other places. It is chiefly contained in the springs of Tarasp, in Switzerland (39 grains in the pound of water), Vichy (29.2), Bilin (24), Preblau (21), Fachingen (17), Ems (15.19), Reinerz (13.8), Teplitz (12.2), Geilnau (12), Neuenahr (10.8), Carlsbad (9.7), Obersalzbrunn (8.81), Sinzig (8.05), Giesshübel (7.09), Selters (6.15), Heilbronn (6), Aix-la-Chapelle and Borcette (5), and Wildungen (2.6). It occurs almost always together with earthy carbonates. It is also found in numerous lakes in India, China, Egypt and the Desert, Hungary, and Columbia. In summer the water of these lakes partly or entirely evaporates, and the carbonate of soda then appears in crystalline efflorescences on the surface of the soil. The carbonate of soda is more easily soluble than the bicarbonate, which latter is therefore

precipitated, if a saturated solution of carbonate of soda is impregnated with carbonic acid.

Carbonate of potash is a very rare ingredient of mineral springs, and when it is found, it is only in extremely minute quantities. It is, however, probable that, if more carefully looked for, it would be found more frequently than it has been up to the present time. The rocks in which it chiefly occurs, are keuper, jura, and felspar.

Carbonate of lithia was, until very lately, even more rarely found in the Spas than carbonate of potash; but quite recently Professor Bunsen has, by means of spectrum analysis, shown that lithia is very generally encountered in nature. It is especially found in lepidolite, a kind of mica which occurs in the granite of Bohemia, and from which it is prepared in chemical manufactories. From one of these fabrics about forty pounds of carbonate of lithia are annually sent to this country, where the salts of lithia are now so much in demand that they can scarcely be supplied in sufficient quantities. The compounds of lithia give rise to two quite distinct spectral rays, one of which is of a feeble yellow, and the other of a very brilliant crimson. By spectrum analysis $^{1}/_{100,000}{}^{\text{th}}$ of a milligramme of carbonate of lithia may be distinctly traced, and one fourth of a grain of the same salt causes the crimson ray to continue for a whole hour. The nature of the compound in which the metal exists, has no influence upon the position of the rays in the spectrum, it being the same with the chloride, the bromide, the iodide,

the carbonate, the sulphate, the phosphate, and the silicate of lithia; but the intensity of the rays increases in proportion to the volatility of the compounds. Professor Bunsen has by this means discovered lithia not only in triphylline, triphane, and petalite, but also in a large nummer of felspars, in the granite of the Odenwald, in a common spring at Schlierbach, near Heidelberg, in sea-water, in fucus which had been carried by the gulf-stream to the shore of Scotland, in the ashes of tobacco, of grapes, of vine-leaves, of grain of every description, of the milk of animals which had been fed upon grain &c. Lithia has also been discovered in the ashes of the human blood and muscles. A very large quantity of it was found in two of the thermal springs of Baden-Baden, namely the Fettquelle and the Murquelle, of which the former contains 0.2315 of chloride of lithium in sixteen ounces of water, and the latter 2.3649 grains of it. In one hundred pounds of the salt extracted from the Murquelle, nine pounds and three quarters of lithia are contained; that is, a quantity of this substance worth ninety pounds sterling. This amount is not equalled by that contained in any other mineral spring which has yet been examined. Lithia is also found in the new Spa of Dürckheim, the mother-lye of which contains 9.7 grains of carbonate of lithia in thousand grains; in the brine-spring, the Racoczi, and Pandur, of Kissingen; and in the mother-lye of Kreuznach, thousand parts of which contain one part of carbonate of lithia. Traces of this substance are also discovered in many other mineral waters, more

especially in such as are rich in chloride of sodium. The statement contained in the "Dictionnaire des Eaux minérales", (Paris 1860), that Carlsbad should contain 1.5 grains of carbonate of lithia, is incorrect. According to Struve, this water contains only 0.026 grains of it, and other chemists have found even less.

If carbonic acid and chlorine are contained in mineral waters together with lithia, it is impossible to show, whether the latter exists as carbonate or as chloride. Carbonate of lithia dissolves in 149 parts of cold water, so that 54 grains of the carbonate might be contained in a cold mineral spring; but no Spa contains so much lithia as the solubility of the compounds of this substance would allow. Chloride of lithium is even more easily soluble than carbonate of lithia; and it seems therefore more in accordance with general principles, to combine lithia with carbonic acid, than lithium with chlorine.

Carbonate of lime is the most abundant of the earthy carbonates. It exists in all sedimentary formations, and constitutes the principal part of numerous mountain ranges. It is found crystallised, as in calcspar, arragonite, granular limestone; and in compact masses, as in common limestone, chalk &c. According to Fresenius, carbonate of lime dissolves in 10,600 parts of cold, and 8834 parts of boiling water; the largest amount of this substance, therefore, which can be contained in a mineral spring, is 0.72 grains in the pound. Bicarbonate of lime is much more easily soluble than the carbonate, as 104 grains of it may be kept in solution by

carbonated water. Common spring water contains generally about four grains of bicarbonate of lime, and is therefore pronounced "hard", when compared with the "soft" rain and river-water which contains a much smaller quantity. Amongst the Spas which contain bicarbonate of lime, Homburg, with 11 grains, and St. Alyre, near Clermont, with 12.5 grains, rank first; Reinerz contains 6.29, Luhatschowitz 4.68, Marienbad 4.63, Bilin 3.08, Salzbrunn 2.02, Carlsbad and Fachingen 2.01, Geilnau 1.98, Selters 1.85 and Giesshübel 1.45. No mineral spring is entirely devoid of bicarbonate of lime. If by the escape of carbonic acid the bicarbonate is changed into carbonate, this latter is deposited; this is the case if the water is heated, or allowed to stand in the air.

Carbonate of magnesia is especially found in dolomite and labrador, but also in serpentine and dolerite. It is therefore not surprising that it should be found in many mineral waters. According to Fresenius, it dissolves in 2500 parts of cold, and 9000 parts of boiling water. Carbonated water absorbs, according to Bischof, 10.4, and according to Struve 111 grains in the pound; a difference which is probably to be ascribed to the different length of time the water has been in contact with the mineral. Göppingen contains 10.6, Courmayeur 6.5, Wildungen 5.54, Tarasp 5.54, Eilsen 4.4 to 5.1, Selters 3.8, Geilnau 2.2, Bilin 1.3 to 2 grains of bicarbonate of magnesia in the pound of water. There are only very few acidulous springs in which no trace of this substance exists.

Carbonate of strontia, which occurs especially in basalt, dissolves in 18,045 parts of cold, 1536 parts of boiling, and 833 parts of carbonated water. It is chiefly found in the Elisenquelle of Kreuznach (0.732 grains), and also in the Adelheidsquelle, in the Sprudel of Carlsbad, in Eger, Ems, Marienbad, and many other Spas, but always in very minute quantities only.

Carbonate of baryta chiefly exists in red and black porphyry, granite, mica and iron ochre. It dissolves, according to Fresenius, in 15,421 parts of cold, 14,137 parts of hot, and according to Lassaigne in 588 parts of carbonated water. Small quantities of this salt are contained in the mineral springs of Ems, Meinberg, Pyrmont, Luhatschowitz, Kreuznach and others.

Carbonate of iron is one of the most abundant of the carbonates, and is frequently accompanied by protoxide of manganese. It occurs in basalt, granite, and dolerite, in dykes and beds of the older rocks, and in sedimentary limestone. Carbonate of iron is quite insoluble in water, and, therefore, if found in mineral springs, only occurs in them as bicarbonate. According to Bischof, one pound of carbonated water dissolves 4.66 grains of the carbonate, or 6.43 grains of the bicarbonate of iron. There are, however, no springs which contain so much of this substance in solution. Some mineral waters contain so little iron, that by the usual method of analysis no trace of it can be discovered, and it is only shown by the deposits of iron ochre in their neighbourhood, that the springs must contain a certain amount of it. Driburg contains 0.85, Pyrmont

0.7, the Stahlbrunnen at Schwalbach 0.64, the Weinbrunnen at the same place 0.44, the Pouhon at Spa 0.37, and Meinberg 0.08 grains of it in sixteen ounces of water.

Carbonate of manganese is almost always found together with iron, and occurs more especially in clay-slate. There is, however, a thermal spring at the Cape which deposits large masses of manganese without iron, and another at Rouen, which contains 0.058 grains of oxide of manganese without a trace of iron. Thirty grains of the carbonate of manganese are soluble in one pound of carbonated water; but about one tenth of a grain is the largest amount of it which has as yet been found in mineral waters. Nauheim contains 0.017 to 0.09, Driburg 0.072, Spa 0.05, Marienbad 0.02 to 0.12, Carlsbad 0.006, and the Stahlbrunnen at Schwalbach 0.1414.

8. CHLORIDES.

We very seldom meet with a fresh water spring which does not contain at least traces of *chloride of sodium* or tablesalt; as this mineral is one of the most abundant of the easily soluble salines. In one pound of water 2027 grains of chloride of sodium may be dissolved, and temperature exerts only a very trifling influence upon its solubility. It occurs in nature in large masses, and in the solid state as well as in solution. Rock-salt forms immense layers, which are found in all sedimentary rocks from the transition to the tertiary

formations, and in the crystalline rocks, basalt, trachyte, pumice-stone, porphyry &c. The different colours of rock-salt are due to admixtures of oxides of metals; it is coloured red or yellow by peroxide of iron, and green by perchloride of iron and sulphur. Immeasurable quantities of chloride of sodium are kept in solution by the sea and numerous salt-lakes. The quantity of tablesalt contained in the former is subject to considerable variations, which are chiefly due to an incomplete mixture of the sea-water with meteoric water. Thus the amount of chloride of sodium in the Mediterranean and Adriatic, was found to vary from 171 grains (near Venice, according to Calamai) to 280 grains (near Messina, according to Ariosto); in the Atlantic, from 191 to 215; in the German ocean, from 179 to 196; in the Baltic from 39 to 95; the Black Sea contains 107.6, the sea of Azoff 74, and the Caspian 27.6 grains of chloride of sodium in the pound of water. Tablesalt lakes exist in Bithynia, Phrygia, Armenia, Persia; the Dead Sea contains 543, and the lake of Lonar, in India, 223 grains of chloride of sodium. Large masses of this substance are also often thrown up by Hecla and Vesuvius.

The brine-springs, of which tablesalt is the chief ingredient, issue generally from the secondary formations, either from beds of rock-salt, or from gypsum and variegated sandstone, in which a considerable quantity of this salt exists. Springs of this kind occur in the greatest abundance in Northern Germany and Aus-

trian Gallicia. Those of Lüneburg contain 1920 grains in the pound, Achselmannstein 1719, Wieliczka 1700, Halle 1365, Castrocaro 759, Montecatini 558, Werl 500, Soest 392, Rodenberg 384, Baden in Switzerland 310, Artern 214, Nauheim 192, Homburg 117, Kissingen 107, Kreuznach 90, Montefalcone 83, Pyrmont 65, Carlsbad 34, Tarasp 30, Ems 7.7, Wildungen 6.7 and Marienbad 1.7.

Hydrochloric acid is found in the lavas of Vesuvius, Stromboli, Lipari, Etna &c.; it is also found in rock-salt, in Bohemian basalt, phonolite, feldspathic porphyry &c. It is evolved if chloride of sodium or of magnesium are heated, and is said to occur in some of the mineral springs of Greece. Free hydrochloric acid is also contained in the water of the Dead Sea.

Chloride of potassium is a much rarer ingredient of springs than chloride of sodium. Amongst others, it is found in the Spas of Wilhelmsbad (16), Soden (3.5), Homburg (2.2) and Wiesbaden (1.2). Mother-lyes contain the largest amount of chloride of potassium, as this salt does not readily crystallise and is easily soluble. In the mother-lye of Kreuznach 168 grains of it are found.

Chloride of Rubidium is extremely similar to chloride of potassium, from which it can be distinguished neither by the ordinary chemical reagents nor by the blow-pipe, but only by means of spectrum analysis. The two metals may be separated from each other by adding perchloride of platinum to their solution, as the compound of chloride of potassium with perchloride of platinum in easily soluble, which is not the case with

the chloride of rubidium. Messrs Bunsen and Kirchhoff have discovered rubidium in lepidolite, in almost all brines, in the Kochbrunnen of Wiesbaden, the Ungemachquelle of Baden, the brine-sprudel of Soden, and the mineral springs of Dürckheim. In 25,000 parts of the mother-lye of the latter Spa, one part of chloride of rubidium is contained. When examined by means of the spectrum, rubidium shows two faint blue, and two strong dark red lines, from which latter its name (rubidus, dark-red) is derived. It is even more electro-positive than potassium, and has an atomic weight of 85.36.

Chloride of Caesium, which has also been discovered by the two philosophers just mentioned, almost always accompanies rubidium, and is most abundantly contained in the brine of Dürckheim; in twenty pounds of which about two milligrammes of chloride of Caesium are found, that is $^1/_{650}$th of a grain in the pound. The water of Kreuznach contains much less of it, and traces are discovered in lepidolite. By adding perchloride of platinum to the salt extracted from the mineral waters of Dürckheim, both chloride of rubidium and of caesium are precipitated; if the deposit is then changed into a carbonate, and absolute alcohol added to it, carbonate of caesium is dissolved. Caesium is the most electro-positive of all substances known up to the present time, and may be recognised by two sky-blue spectral lines, from which the name of caesium has been given it, and by which alone it can be distinguished from potassium and rubidium. Its atomic

weight is 123.4, and is only surpassed by that of gold and iodine.

Chloride of magnesium is easily soluble, and found in many mineral waters, such as Kissingen (24.5), Friedrichshall (30.25), Pyrmont (7 to 12), Homburg (6 to 7.8), Bath (1.6), Wiesbaden (1 grain). As mineral it occurs in porphyry, granite and rock-salt. The Dead Sea contains no less than 904 grains of it in 16 ounces.

Chloride of iron is comparatively rare in mineral waters. It is found in the springs of Neudorf (0.068), Buckowina (0.4 to 0.9), Alexisbad (1) and Wieliczka (3).

Chloride of calcium is extremely soluble, and occurs chiefly in brines. The Dead Sea contains 246 grains of it, the large Sprudel of Nauheim 14.86, the brine of Hall 0.92, and Wittekind, near Halle 3.13.

9. IODIDES.

M. Cantu has laid down the general rule that, wherever chlorides exist, iodides and bromides may also be found; and Chatin has discovered iodine not only in sea-water and sea-weeds, but also in fresh-water plants, in most springs, in the atmosphere, in rainwater and rivers. In the Spas, iodine is generally combined with sodium. The brine-spring of Kissingen contains 0.0000017 grains of iodine, the Kesselbrunnen of Ems 0.00008, Challes and San Ginesio in Piedmont 0.038, the Adelheidsquelle of Heilbronn 0.15 to 0.9, Castrocaro in Tuscany 0.67, Hall 0.3, Tölz 0.29, Kreuznach 0.0025 to 0.035, and Dürckheim 0.0068 to 0.016. Iodine is more easily ex-

tracted from rocks if the water contains alkalines in solution, and has a high temperature.

10. BROMIDES.

Bromine always accompanies iodine, and is generally combined with magnesium. The waters of Luhatschowitz contain 0.3, Hall 0.45, Kreuznach (Oranienquelle) 1.78, Castrocaro 0.072; and the mother-lyes of Kreuznach 76, of Rehme 250, and of Neu Salzwerk 1173 grains of bromide of magnesium. In the Dead Sea 33 grains of this substance are found.

11. SULPHATES.

Sulphates, although very prevalent in springs, are not of such general occurrence in them as chlorides. The largest quantities are contained in the bitter-waters of Bohemia.

Sulphate of soda is found in a considerable number of mineral waters. Carlsbad contains 19, Eger 25, Saidschütz 27, Friedrichshall 46.5, and Püllna even 124 grains of it. It form the chief ingredient of the indifferent thermal springs of Gastein and Warmbrunn. The salt is derived from basalt, felspar, porphyry, mica, granite and other rocks; and it also occurs in efflorescences of the soil, especially in the steppes of Siberia, and the plains of South America.

Sulphate of magnesia occurs, as mineral, especially in marl, serpentine, limestone and clay-slate. In mineral waters it is generally found together with sulphate of soda, or chloride of sodium, or with both. The springs

of Montecatini contain 17, those of Windsor Forest 18, Kösen 21, Friedrichshall 39, Saidschütz 84, Sedlitz 104, Epsom 240, Kilburn 248, and Gran 718 grains in the pound. This salt is also found in great abundance in a number of mineral springs in the Caucasus.

Sulphate of lime, or gypsum, dissolves in 400 to 460 parts of water, so that one pound of water cannot contain more than 17 to 19 grains of it. If chloride of sodium is present, the solubility of gypsum is increased; but carbonic acid has not the same effect. Brines may, for this reason, contain a larger amount of sulphate of lime than other springs. Such is the case with Rehme (23), Kösen (31), Sulz (39). Gypsum is also contained in the springs of Pyrmont and Eilsen (14 each), Leuk or Louèche (12.3), Lucca (13), Baden in Switzerland (10.8), Driburg (8.4 to 10.6), Nenndorf 5.8 to 7.6), Bagnères d'Adour (5.8) and Pisa (2). As mineral, sulphate of lime does not occur in crystalline rocks or primary formations; but it abounds in red sandstone, and in the fissures of porphyry, basalt, and granite. It is often found together with sulphur, in which case both these substances are products of a decomposition of sulphuretted hydrogen.

Sulphate of potash generally accompanies sulphate of soda. It has up to the present time only been found in a small number of springs; but it is probable that it would be discovered more frequently, if it were looked for with greater care. Struve discovered 1.2 to 1.9 grains of it in the water of Carlsbad, and 4.8 in that of Püllna. It is also found in Tarasp (2.64), Ma-

rienbad (2), Bilin (1.7), Vichy (1.5), Franzensbad (0.96), Ems (0.87), Selters (0.3) and some others.

Sulphate of iron is also a rare constituent of mineral springs. It is met with in springs flowing through rocks containing sulphuret of iron, which substance is, by oxidation, changed into sulphate of iron. Such are the springs of Alexisbad (0.57 to 1.7), Muskau (0.88), Giglio (4.8), Cransac (7.7), and Ronneby in Sweden (8). The acqua di Vigneria, in the island of Elba, contains four grains of sulphate of iron and 5.5 of sulphuric acid; and the acqua ferrata di Rio, in the same island, even 22 grains of the sulphate of iron and 26 of sulphuric acid. These waters are so strong that they cannot be used for medical purposes unless previously diluted.

Sulphate of alumina sometimes accompanies the sulphate of iron. The spring of Vicar's-Bridge, in Scotland, is said to contain 59 grains, and those of Zovany, in Transylvania, 66 grains of it in sixteen ounces. Springs containing this substance are, however, most frequent in Italy, where the cold acidulous spring of Misterbianco contains 1.8 grains, the thermals of Mondragone 6 to 7, that of Subveni Homini 5 to 6, and the Pisciarella 13 grains.

Sulphate of strontia is only soluble in 6895 parts of water at a temperature of 57°, and of 9688 at 212°, so that only 0.5 to 1.11 grains can be contained in mineral waters. This amount, however, has never yet been discovered in any Spa, traces only of this substance being found in them.

Sulphate of baryta is only soluble in 43,000 parts of water at the ordinary temperature, but it is rendered more soluble if silicate of strontia is at the same time present. If sulphate of baryta is found together with carbonate of soda, at a temperature of 86°, a decomposition is effected, carbonate of baryta and sulphate of soda being formed; but if the water cools down to 66°, sulphate of baryta is again formed. This latter is probably contained in many mineral waters, but in such minute quantities that it has hitherto generally escaped observation.

12. SILICATES.

Silica is contained in the water of almost every spring. It occurs in a soluble and an insoluble state, and is most readily dissolved, when it comes in contact with a hot and somewhat concentrated solution of alkaline carbonates. Some of the earthy silicates are almost entirely insoluble; thus, for instance, the silicate of alumina only dissolves in 179,000 to 334,600 parts, and the silicate of magnesia in 32,400 to 90,600 parts of water; while silicate of lime dissolves in 5400 to 19,400 parts, so that sixteen ounces of water may contain one grain of the latter compound. Silicate of strontia is even more soluble. Thermal springs always contain more silica than cold ones. According to Brewster, the hot springs of Pinnarcoon and Loorgootha, in India, contain 21 parts of silica in a hundred parts of solid ingredients; a spring at Arles has 30, one at Luxeuil 50 percent, and the crucifix-spring, at Plombières,

contains scarcely anything else but silica. In the waters of Kissingen 1.5 to 2.25, in those of Wiesbaden 1.4, in Bourbon l'Archambault 3.3, and in the Geysers of Iceland 3.14 grains of silicates, are contained. A considerable amount of silicates is also found in the ashes of a number of plants, which must have derived it from water; and as a mineral, silica constitutes a very large portion of the earth's surface, being found in felspar, clay, quartz, rock-crystal, chalcedony, sand, and many other substances.

13. PHOSPHATES.

Minute quantities of phosphoric acid may be discovered in the water of almost every spring. Phosphates occur in chalk, dolomite, slate, basalt, mica, granite, trachite, apatite, and many other formations, and would probably be found in much larger quantities in mineral waters if the alkaline phosphates, which are easily soluble, were not precipitated by iron, alumina, and lime. Phosphate of iron is only soluble in seven million parts of carbonated water, and phosphate of lime (as apatite), in 400,000 parts, while the artificially produced phosphate of lime may be dissolved in 1100 to 1500 parts of water. Its solubility is slightly increased if chloride of sodium is also present. In three million parts of Carlsbad water one part of phosphate of alumina is contained. Small quantities of this substance are also contained in the Spas of Aix-la-Chapelle and Wildegg. One grain of phosphate of soda is contained in 588 pounds of Ems water, 348 pounds of

Marienbad, 308 of Püllna, 156 of Homburg, 53 of Teplitz, 31 of Vichy, and 12 of Pyrmont.

14. BORACIC ACID.

In the Maremmas of Tuscany, near Possara, Castel nuovo and Monte Cerboli, eruptions of hot vapours (suffioni) occur, which issue from fissures of rocks and pools (lagunes), and ascend into the air in thick white clouds. They consist of carbonic acid, nitrogen, oxygen, sulphuretted hydrogen and sulphuric acid, and carry with them a considerable quantity of sulphate of lime, ammonia, alumina, iron, and boracic acid. On the edge of the pools a salt is precipitated, which consists chiefly of boracic acid and sulphate of ammonia. Boracic acid also occurs in the steam rising from the crater of Volcano, one of the Lipari Isles; in certain lakes in India, Ceylon and China; and in the thermal springs of Wiesbaden and Schlangenbad. Traces of it are also found in the waters of Aix-la-Chapelle. The minerals in which boracic acid is chiefly contained, are tourmaline, mica, felspar, borax, hydroboracite, and a few others.

15. FLUORIDES.

In minerals fluorine is generally found combined with calcium, magnesium and aluminium, and occurs chiefly in mica, lepidolite and hornblende. In one pound of water 6.285 grains of fluoride of calcium may be dissolved; it is more easily soluble in a hot solution of alkaline carbonates. Small quantities of it have been discovered in the waters of Carlsbad (0.015),

Ems (0.021), Aix la Chapelle (0.46) and Selters (0.0016). The Sprudelstein, which is deposited by the springs of Carlsbad, contains 6 9 to 9.9 parts of fluoride of calcium in a thousand parts.

16. NITRIC ACID.

This substance is found in meteoric water, especially during storms, when ozone combines with nitrogen to form nitric acid. It is, however, chiefly formed by the decomposition of organic matter, and is generally met with in the wells of large towns. The springs of Wildegg contain 0.59 grains of nitrate of soda, those of St. Albano 2.5 grains of nitrate of lime, Püllna 4.6 of nitrate of magnesia, and Seidschütz even from 8 to 25 grains of the latter compound.

17. ARSENIC.

Small quantities of this substance are found in a number of mineral waters; such as Mescutin, Driburg, Vichy, Wiesbaden, Soden, Homburg, Schwalbach, and in all the sulphurous springs of the Pyrenees. The Grande Grille of Vichy contains 0.014 grains of arseniate of soda, and Driburg 0,0002 grains of arsenious acid.

Antimony occurs in the Spas of Brückenau, Kissingen, Rippoldsau, Wiesbaden &c.; and traces of zinc, copper, tin, lead, tantal, wolfram, yttrium and other metals have also been discovered in a number of mineral springs.

I now proceed to consider the organic ingredients of the mineral waters.

18. PETROLEUM AND NAPHTHA.

Springs of naphtha, petroleum and mineral pitch, are found in several places, as Zante, Modena, Parma, Girgenti &c. In the Burmese territory, on the Irawaddy, there are upwards of 500 wells yielding annually 400,000 hogsheads of petroleum; and in Trinidad there is a lake of mineral pitch, partly liquid and partly solid, and three miles in circumference; fluid bitumen also rises to the surface of the sea near that island.

19. ORGANIC ACIDS.

In many mineral waters we meet with organic acids, especially crenic and apocrenic acids, which do not contain any nitrogen, and are the product of the decomposition of humus. Some of these acids form soluble compounds with alkalies. In the Kanitz-spring, near Partenkirchen, a peculiar acid has been discovered, which contains nitrogen, and is said to impart a sweet taste to the water.

20. BAREGINE.

Many thermal springs are distinguished by a peculiar smell and taste similar to beaf-tea; the smell being especially perceptible, if the water is made to evaporate; and in the neighbourhood of such springs, gelatinous deposits are often met with. They are mostly amorphous, uncoloured and transparent; but sometimes

they appear yellow, green, brown, or even black, and contain cells and tubes. The most remarkable deposits of this kind are found in Ischia, where thermal waters containing nitrogenous substances run down steep rocks, and organic membranes are formed which have a thickness of several inches. Such substances are also found in the sulphurous springs of the Pyrenees, in Gastein, Wiesbaden, and elsewhere. From having been first discovered in large quantities at Barèges, this matter was called Barègine by M. Longchamps. Gimbernat, who found it in the vapours emitted by many thermal springs, by Vesuvius, and the solfatara of Puzzuoli, called it zoogène, while Anglada termed it glairine, and Monhain theio-thermine, from being chiefly found in sulphurous thermal springs. Berthier, who never observed this substance at the immediate point of egress of the springs, believed it to be due to the action of light and air upon water; and Fabroni thought that it came from the layers of fossile bones, over and through which the water passed in the interior. M. Fontan discovered a delicate conferva in the deposits of sulphurous springs, which he called sulphuraire; and Alibert believed baregine to be due to a decomposition of this plant. M. Lambron declared for Alibert's view, and stated that in the process of decomposition two different substances were formed; the coat of the sulphuraire was changed into a sort of mucus, and its internal substance into a heavy, soapy mass, which assumed different colours according to the nature of the substances with which it came in contact.

M. Bonjean, who has more recently investigated the subject, distinguishes two substances, which he calls glairine and glairidine. Glairine is, according to him, deposited wherever sulphurous thermal waters come in contact with the atmosphere; it contains little nitrogen and no iodine, is scarcely soluble in water, and insoluble in ether; after having been exposed to the atmosphere for some time, it turns grey, and when dried looks like horn. Glairidine, on the other hand, is deposited when rain-water mixes with sulphurous springs; it is dark grey, and turns green on the addition of alkalies; it contains traces of iodine, and is quite insoluble in water and ether. Laborious as the researches hitherto undertaken on this substance no doubt have been, it must be acknowledged, that the subject is very far from being satisfactorily cleared up, and further investigations of it appear to be very necessary.

21. PLANTS AND INFUSORIA.

Besides M. Fontan's sulphuraire mentioned above, no less than ten species of confervae and two ulvae, have been discovered in a number of mineral waters. Most of the infusoria which were formerly believed to exist in the Spas, have been shown to be vegetable organisms. Such is, for instance, the case with the Gallionella ferruginea Ehrenberg, which is contained in almost all chalybeates, and forms the greatest part of the yellow ochre which is deposited by them. Vegetable organisms containing iodine have been found in the waters of Vichy, Néris, Evaux and Montecatini.

Such are the principal facts at present known regarding the chemical composition of mineral waters. It now only remains for us to consider, whether it is possible to attempt a scientific classification of the Spas according to their chemical composition.

From the foregoing it is quite evident, that it would be vain to endeavour tracing a distinct line of demarcation between the many different groups of mineral waters; for although a certain number of them have decidedly characteristic features, there are, on the other hand, a great many springs which unite the properties belonging to several other groups; and for this reason all classifications which may have been made, and may yet be made, must be considered as devoid of philosophical exactness, and as a mere matter of convenience, and aid to the memory. As such only I should wish to see considered the following

CLASSIFICATION OF MINERAL WATERS

ACCORDING TO THEIR CHEMICAL COMPOSITION.

1. ALKALINE SPRINGS.

a. *Alkaline acidulous springs.*

Chief Contents: Carbonic acid and bicarbonate of soda.

Representative: *Vichy.*

b. *Alkaline muriated acidulous springs.*

Chief Contents: Carbonic acid, chloride of sodium, and bicarbonate of soda.

Representative: *Ems.*

c. *Alkaline saline springs.*

Chief Contents: bicarbonate and sulphate of soda.

Representative: *Carlsbad.*

2. BITTER-WATERS.

Chief Contents: Sulphates of soda and magnesia.

Representative: *Friedrichshall.*

3. MURIATED WATERS.

a. *simple muriated waters.*

Chief Contents: a moderate amount of chloride of sodium.

Representative: *Wiesbaden.*

b. *muriated lithia waters.*

Chief Contents: chlorides of sodium and lithium.

Representative: *Baden-Baden* (Murquelle).

c. *brines.*

Chief Contents: a large amount of chloride of sodium.

Representative: *Rehme.*

d. *iodated muriated springs.*

Chief Contents: iodide of sodium.

Representative: *Castrocaro.*

e. *bromated muriated springs.*

Chief Contents: bromide of magnesium.

Representative: *Kreuznach* (Oranienquelle).

4. EARTHY SPRINGS.

Chief Contents: carbonate and sulphate of lime.

Representative: *Leuk* (Louèche).

5. INDIFFERENT THERMAL SPRINGS.
   Chief Contents: a very small amount of salines.
   Representative: *Gastein.*

6. CHALYBEATES.
   a. *Acidulous chalybeates.*
   Chief Contents: carbonic acid and bicarbonate of protoxide of iron.
   Representative: *Schwalbach.*
   b. *Saline acidulous chalybeates.*
   Chief Contents: Sulphate of soda and bicarbonate of protoxide of iron.
   Representative: *Franzensbad.*

7. SULPHUROUS SPRINGS.
   a. *Springs containing sulphuretted hydrogen.*
   Representative: *Eilsen.*
   b. *Springs containing sulphurets of metals.*
   Representative: *Bagnères de Luchon.*

CHAPTER IV.

THE GEOGRAPHICAL DISTRIBUTION OF MINERAL WATERS.

There is probably no country in the world which does not contain some mineral waters. In China, Japan, Kamtshatka, Java, Sumatra, India, and Ceylon, there are numerous sulphurous thermal and cold acidulous springs, as well as exhalations of steam and of carburetted and sulphuretted hydrogen. At Yakutsk, in Siberia, where the soil is frozen to a depth of 630 feet below the surface, hot springs rise from far deeper points, and break forth through ice and snow. The Steppes which extend from the Caspian Sea in a north-easterly direction, are full of lakes and springs containing soda and magnesia. Arabia possesses many thermal waters, and on the road from Mecca to Medina there is scarcely a station without one. The Spas of Erzeroum, in Armenia, and of Tiflis, in Georgia, have been renowned for centuries. The Dead Sea, or lake of Sodom, is one huge mineral water, or rather mother-lye, which contains twenty-five per cent of solid constituents, and the specific gravity of the water is so great that it is difficult to sink in it. Numerous mineral waters are also met with in Africa, especially in the Azores and the Canary Isles, along the northern Coast, in the Oases of the Desert, and the Cape of Good Hope.

Numbers of hot mineral waters issue from the Andes, in South America, and from the chains of the Rocky and Alleghanny mountains of North America, while many cold mineral spings are found along the Atlantic Coast of that Continent. Hot springs are plentiful in Mexico, and the West India islands; and several have also been found in Australia.

The most important mineral waters, however, exist in Europe. The Geysers, in Iceland, present a spectacle unsurpassed in magnificence by any other thermals. In Sweden and Norway there is a certain number of cold mineral waters, but only very few thermals, and no real hot springs, probably because in the soil of those countries there is no alternation of crystalline rocks and sedimentary formations, which favours the issue of such springs. Mineral waters are rare in the North of Russia, and Poland. In Ireland there is but one thermal spring, that of Mallow; most of the mineral waters in that country being cold saline, chalybeate, and sulphurous. Scotland does not contain any warm springs whatever, but a few strong sulphurous waters, such as Strathpeffer, in Rosshire, and Moffat, in Dumfriesshire, as well as a few salines and chalybeates are to be found there. In England the chief mineral waters are the muriatic gypsum thermal springs of Bath, the "Aquae Calidae" or "Sudatae" of the Romans; the indifferent thermals of Buxton and Bristol; the brines of Droitwich, Kingswood, and Ashby-de-la-Zouch; the Purton Spa, in Wiltshire, which contains iodine and bromine; the calcareous

bitter-water of Epsom; the muriatic springs of Harrowgate; the alkalines of Malvern, the muriatic alkalines of Leamington, the muriatic salines and chalybeates of Cheltenham, and the alkaline chalybeate of Scarborough.

Spain is rich in mineral waters, which are calculated at 1200; but they are at present only very imperfectly known. By far the greater number of them are sulphurous thermals; the remainder, with the exception of a few acidulous alkalines, brines and bitter-waters, being cold chalybeates. The provinces of Granada, Seville, and Biscaya, are richest in mineral waters; but the most celebrated are the hot springs of Fuente Caliente, in Valencia, the cold springs of Monistrol Tortosa, and the hot springs of Pentacosa, in Aragon, and of Malavilla, in Catalonia.

Portugal contains upwards of two hundred mineral waters, amongst which sulphurous thermals also predominate. They are most numerous in the provinces of Estremadura, Tra los Montes, and Minho. Those most renowned for their curative powers are the baths of Caldas da Raynha, near Torres Vedras, and the indifferent thermals of Caldas de Geres.

There are many remarkable mineral waters in Greece, such as the incrustating hot springs of Thermopylae, from which that place derived its name. They have a temperature of 149°, and contain chiefly chloride of sodium, sulphate of magnesia, and bicarbonate of lime. The quantity of water furnished by them is very large, and it deposits stony concretions on its way to the sea

which is about one mile distant. The soil in the neighbourhood of the springs gives a hollow sound when trodden upon, the same as is the case with the Solfatara, at Naples. These springs are annually visited by large numbers of natives, first in the month of May, when they go merely to look at the springs, and afterwards in August, for the purpose of bathing. In ancient times the springs were sacred to Hercules, and Herodes Atticus erected splendid bathing establishments near them; but nothing of this kind is to be found there at the present time. Near Thermopylae the muriated sulphurous springs of Hypate, which were renowned in antiquity, are still to be seen. In the convent of Caesariana, at the foot of Hymettus, near Athens, muriated waters exist which are even now much frequented by convalescents, and persons suffering from diseases of the eye. The thermals of Aedepsos, or Dipso, in Euboea (Negroponte), the composition of which resembles that of the Wiesbaden waters, are also annually visited by a large number of Greeks. Many sulphurous thermal springs are met with in the Archipelagus, the formation of which is altogether of a volcanic nature.

The island of Pantellaria, between Sicily and Africa, forms, as it were, a large crater, 2000 feet high, and from all sides of which steam and thermal springs issue.

Sicily contains a very large number of mineral waters, amongst which may be mentioned the sulphurous springs of Segesta (Aquae Segestanae), nine miglie

from Alcamo, on the road from Palermo to Trapani, which have a temperature of 165°, and contain sulphuretted hydrogen, carbonic acid and tablesalt; the sulphurous baths of Sciacca (Selinunt), close to the sea, of various temperatures, and which are very much used in diseases of the skin, palsies, and rheumatism; and the steam-baths in the grottoes of Mount Calogero, which were already resorted to by the Phoenicians, and were believed to have been discovered by Daedalus. In olden times there existed at the latter place a hospital for the reception of the sick, who in the month of June came to the springs, from all parts of Sicily; and some stone-benches, upon which the names of those who had been cured were inscribed, are still to be seen in the grottoes. The waters are used for gout, rheumatism, paralysis, skin diseases, and deafness; in cases of the latter affection the steam is conducted to the ears by means of tubes. Near Palermo many hot springs rise from the bottom of the sea. The sulphurous springs of Termini (Thermae Himerenses), on the road from Palermo to Messina, in the Val di Mazzara, were first used by the Carthaginians, during the Punic wars; and afterwards by the Romans. In 1832 many wounded soldiers of the Austrian army which had just then occupied Naples, were cured there. Of high repute are also the springs of Sorgente di Saccha, near the Monte delle Gemme, where aqueous vapours rise in grottoes. Cold acidulous springs exist at Paterno; the lake of Palici, near the town of Bivona, contains large masses of petroleum which floats

on the surface, and is used by the inhabitants for helminthiasis; and at the foot of the Etna, near Aci Reale, there rise the sulphurous springs of Santa Vennera.

The Neapolitan States also abound in mineral waters. One of the most remarkable amongst them is the lake of Amsanctus, near Fricenti, in the province of Principato ulteriore. It lies in a gloomy valley of volcanic formation, and has a circumference of 110 feet. The water, which contains a large quantity of sulphuretted hydrogen and carbonic acid, is thick and as black as ink. It has a foul smell, and its surface is in perpetual bubbling motion. The whizzing and spouting is strongest in the middle of the lake, where the water is sometimes thrown up to the height of from two to five feet. The gas which escapes from the lake, is absolutely irrespirable, and kills those who venture too close to it. It is most dangerous in the height of summer, when the water dries up, and strong currents of gas escape from the bottom of the lake. After rains, and when the bed is filled with water, the quantity and intensity of the gas are lessened.

Amongst the mineral waters found in the territory immediately adjoining the gulf of Naples, I will mention the acqua sulphurea di S. Lucia; the acqua ferrata di Pizzofalcone, the Therma della Pietra, which chiefly contains bicarbonate of soda and is similar to the springs of Vichy; the thermal spring of Subveni Homini, at the foot of Mount Olibano; the Acqua Vesuviana Nunziante; the Acqua di Bagni, or Serapis' bath, where a temple of Serapis formerly existed; the

springs of Puzzuoli; the Stufa di Nerone (166°), near Tritoli, in a westerly direction from the lake of Averno, which contains pure steam, and where in the depth of the grotto a spring is found which is near boiling point; the Stufa di S. Germano, on the south-western shore of the lake Agnano, a hundred yards from the Grotta Canina, and which contains steam, sulphuretted hydrogen, and carbonic acid, and produces very strong diaphoretic effects. The air in the Grotta Canina, the walls of which are formed by volcanic tufa, consists of 80 percent of carbonic acid, and 20 parts of nitrogen, and paralyses the lungs and the brain of all who breathe it. The gas generally rises only from six to eight inches above the ground, where it forms a greyish white cloud; and it is only when the heat is great and the atmosphere very clear that it ascends as high as twelve inches. Finally I will mention the springs of Bajae (the "Ruina dei Vecchii e dei Giovani") which was beautifully situated on two bays separated by the Cape of Miseno, and was the centre of fashion and luxury at the time of the Roman Emperors. The last remains of the town were destroyed by an earthquake in the fourteenth century; but some ruins of Nero's baths exist even now, and theNeapolitans are accustomed to use the steam-baths of Bajae, in the height of summer, for rheumatism.

Ischia is full of mineral waters and stufe. They are most abundant on and near Mount Epomeo, a volcano 1860 feet high, which has been extinct since 1301. Amongst the mineral waters of this island, I may men-

tion the Acque del Bagno d'Ischia, del Olmitello, del Gurgitello, di Castiglione, di Santa Restituta; and amongst the stufe those of Castiglione, S. Lorenzo, Testaccio and Gurgitello. Ischia is also celebrated for its arenations or sand-baths. In many places there, the soil is formed of a sort of moist mineralised sand which has a high temperature. Pits are dug into this, at first one foot deep; the depth is afterwards gradually increased to two feet and a half. At a depth of three feet mineral water is encountered. Into these beds the patient is placed, for from a quarter to three quarters of an hour, and covered up to the neck with a layer of sand of from eight to ten inches thick. The sensation produced by this is by no means unpleasant. The temperature differs from 108° to 133°, according to the depth. These arenations excite a powerful perspiration, and accelerate the pulse; they are much prescribed by the Italian physicians for rheumatic gout, palsy, oedema, scrofula and diseases of the skin.

In the Papal States there is the sulphurous aqua Albula, near Tivoli, whose praises have been sung by Virgil. The spirit of Faunus, the father of King Latinus, was believed to reside in these springs, and the priests therefore declared them to be sacred. The Albula is one of the few mineral waters the medicinal use of which was recommended by Galenus; it was used by Augustus, Nero, and Zenobia, Queen of Palmyra. The water rises in the Campagna, about fifteen miles from Rome, from two lakes which were once craters of volcanoes; some of the springs are hot, others

cold, and the mixture has, in the second lake, a temperature of 77°. The springs have no natural outlet, and the inhabitants of Tibur therefore soon found it necessary to form a canal for preventing the neighbouring fields from being inundated by the surplus water. This canal was renovated by the Emperor Augustus, and bathing establishments were erected on the spot by Marcus Agrippa. In the course of time the canal became obstructed with lime-sinter, and was, in the sixteenth century, re-established by the Cardinal Hippolyte d'Este, who built the villa d'Este, near Tivoli. The water now flows into the Teverone, the Anio of the ancients. Albula is called by the inhabitants Lago di Golfo, or Lago delle Isole Natante, from the floating islands which exist in it. The water, when placed in a tumbler, is quite clear; its taste is nauseous, acid, and sulphurous; and it is now only used for bathing. In serene weather, and if the wind is favourable, the smell is carried as far as Rome. Persons who are on the lake, experience an unpleasant oppression on the chest, and fulness in the head. Sebastiani mentions that, if any one bathes in this water and inspires the gas as it rises from the surface, death ensues immediately; and that in the last century a whole family had been killed by the emanations of the lake. This is, however, not affirmed by other writers.

In the immediate neighbourhood of Rome there is an acidulous spring, the Acqua Acetosa, which is close to the Arco Oscuro, outside the Porta del Popolo; and at a distance of a short day's journey from Rome,

there are the Bagni di Stigliano (Aquae Stygianae or Apollinares). These latter are more important than the aqua Albula, as they contain not only a very large amount of sulphur, but also iodine, besides which they have a higher temperature, which amounts to from 100° to 122°, and which very much exalts their physiological effects and their curative powers.

The mineral waters of Viterbo, one of which is a cold acidulous chalybeate, and the other a warm sulphurous spring, are also very much employed. "These "waters" (says Dr Erhardt, of Rome, in a letter to the author) "have escaped the fate of seeing their celebrity "covered for centuries with grass, and their ancient "contrivances for bathing overgrown with ivy. On the "contrary, they have always been greatly esteemed, "while those of Tivoli and Stigliano were for a long "time given up to archaeology, and have only within "the last decennium been restored to balneo-thera-"peutics."

Tuscany, which has an area of 1975 square miles, possesses a comparatively larger number of mineral waters than any other country. According to Giuseppe Giulii, there are no less than 231 real mineral springs there, independently of sixty-four others which are either mere lagunes and steam-baths, and unfit for medical use, or intermittent springs, or which were erroneously believed to be mineral waters by previous observers. Amongst the Tuscan mineral springs, I will chiefly mention the Acqua Borra, near Siena, and the Acqua Petriolo; the thermal springs of Montecatini,

near Pistoja, and those of S. Giuliano, near Pisa, which were greatly renowned in antiquity, and re-established in the twelvth century, by the Countess Mathilde; these latter contain chiefly sulphates and carbonates, and are especially used for gout and liver-diseases. One of the most important mineral waters of Tuscany is that of Castrocaro, a small place in the Tuscan Romagna, on the Eastern slope of the Apennines, five miles from Forli, and consequently within walking distance of the terminus of the railway recently opened, and which connects these mountainous districts with Bologna. "Although the springs of Castrocaro" (says Dr Grisanowski, of Pisa, in a letter to the author) "are sup-"posed to have been known by the ancient Romans, "who called the place Salsubium, they seem afterwards "to have fallen into utter oblivion, and remained un-"heeded for centuries, until some five-and-twenty years "ago a mere accident attracted public attention to them. "A few pounds of salt, suspected of not coming from "the legitimate source of Grand-Ducal manufacture, "were confiscated and analysed, and were found to con-"tain a considerable quantity of iodine and other un-"lawful ingredients. This led to further, although very "tardy, investigations, and it was at last discovered that "the inhabitants of those districts had from time imme-"morial been in the habit of encroaching upon the Grand-"Ducal privilege, by procuring salt mfro the saline ex-"udations, which, especially during dry weather, cover "the conchyliferous tufa of those mountains. The bad "taste of this salt, to which the people were reconciled

"only by its cheapness, very naturally gave rise "to a superstitious belief in its prophylactic and cura-"tive powers, which were invoked against every imagin-"able disease. But it was only in 1845, that the water "itself of the Castrocaro springs was subjected to an "accurate analysis by Dr Antonio Targioni Tozzeti, who "found in twelve ounces of this water 3.90 grains of "iodide of sodium and 0.06 of bromide of sodium."

The baths of Lucca have for centuries been extensively employed; they contain chiefly sulphates, but also carbonates, iron, and chloride of sodium, and have a temperature varying from 75° to 109°; the strongest of these waters is that of Doccione.

Piedmont is rich in sulphurous waters, amongst which those of Valdieri, Vinadio, S. Roccabigliera, and Craveggio, deserve to be specially mentioned.

A large number of thermal springs issue from the Euganean hills, in the neighbourhood of Padua. Amongst these (the "fontes Patavini" of the Romans) the waters of Abano, a small town, which is only thirty feet above the level of the sea, rank first in importance. Six thermal springs rise there from a limestone rock, and form several rivulets and a lake which has a circumference of a hundred and twenty feet. The water is dark blue, and opaque. Its specific gravity is 1040, its temperature 181°. The grey clouds which ascend from this water consist of sulphuretted hydrogen, steam, and salts carried up by the vapour. The water contains chiefly chloride of sodium, and sulphate and carbonate of lime, but also iodide and bromide of magne-

sium. In the neighbourhood of Abano many other thermal springs are found, such as those of Monte Ortone, S. Pietro Montagnone, Montegrotto, Battaglia, Casa nuova, S. Bartolommeo, and S. Elena.

France, with an area of about 50,000 square miles, possesses 474 thermal springs, of which 248 are in the Pyrenees; and 218 cold mineral waters, amongst which are 172 chalybeates. The most important Spa in the newly-annexed province of Savoy is Aix-les-Bains, in the valley of Chambery, eight hundred feet above the sea, and ninety feet above the lake of Bourguet; where sulphurous thermal waters rise from limestone rocks. Close to Aix, there are the cold sulphurous waters of Marlioz, which contain more sulphur than the chief springs of the Pyrenees; the waters of Challes, in which a considerable amount of sulphate of soda, bromide of sodium, and iodide of potassium is found; the springs of Coeze, in the valley of the Isère, which contain iodide of magnesium, bromide of sodium, and bicarbonate of soda; finally the chalybeate spring of St. Simon.

The Spas of the Pyrenees are mostly sulphurous. Amongst these the following are most important: Bagnères de Luchon (Thermae Luxovienses), close to the Spanish frontier, 1836 feet above the level of the sea, in a valley where 38 copious springs rise from slate and granite; Bagnères de Bigorre, 1740 feet, on the Adour, in the Hautes Pyrenees, with 24 springs; Barèges, 3723 feet, in a very narrow and wild valley, where eight thermal springs rise from granite and clay-slate; Eaux Chaudes 2034 feet, near Pau, in a dark

mountain ravine; Eaux Bonnes, 2370 feet, Chaudes Aigues (Aquae Calidae), between Clermont and Toulouse; and St. Sauveur, 2280 feet, near Barèges, in an extremely picturesque neighbourhood.

Another group of French mineral waters are found in the Auvergne. These contain chiefly carbonic acid and bicarbonate of soda, and Vichy is the most important amongst them. This place is situated in the valley of the river Allier, 787 feet above the Sea, and has a high temperature in summer. A large number of acidulous alkaline springs, with a temperature varying from 50° to 107°, rise there from limestone which overlies granite. Springs of the same chemical composition abound in the surrounding neighbourhood, more especially in Hauterive, Cusset, d'Abrest, and St. Yorre.

France also contains a number of muriated springs, the principal of which are those of Bourbonne-les-Bains, 870 feet above the sea, in the Département of the Haute Marne; which rise from granite and are analogous to those of Baden-Baden and Wiesbaden. To this place, after a campaign, the wounded soldiers of the French army are sent with preference. Similar springs are those of Bourbon-Lancy, in the Département of Saône and Loire; and those of Bourbon l'Archambault, 1710 feet, in the Département Allier. Amongst the saline muriated sulphurous waters, Uriage, near Grenoble, in the Département of the Isère, deserves to be mentioned. Luxeuil, in the Département of Haute Saône, on the foot of the Vosges, possesses saline chalybeates; the

springs of Enghien contain sulphate of iron, and those of Passy bicarbonate of iron. Plombières, in a valley of the Vosges, 1310 feet, is an excellent "indifferent thermal" Spa.

Switzerland, although small, contains several mineral waters remarkable for their composition and their curative powers, which latter are no doubt enhanced by the grand scenery and the pure Alpine air of the country. The majority of the mineral waters in the valley of the Rhone are gypsum springs; those in the valley of the Inn being acidulous alkalines and chalybeates. The greatest number of Spas are found in the canton of Berne, while Zug, Uri, Schwyz, Unterwalden, Geneva, Schaffhausen, Zurich and Lucerne, contain only very few or none at all.

In the canton of Vaud, the saline muriated sulphurous thermal springs of Lavey, on the right bank of the Rhone, and close to the road from Lausanne to the Simplon, deserve to be noticed. These springs are remarkable for the great variations of temperature which occur in them, and are much employed in rheumatism, diseases of the skin, and scrofula. In the same canton, the sulphurous thermals and the brine of Bex, 1293 feet above the sea, are found, where a mother-lye is prepared which is extensively employed; also the sulphurous gypsum spring of l'Allias, six miles from Vevey, 3215 feet above the sea; the cold sulphurous spring of l'Etivaz, 3250 feet, and the alkaline sulphurous springs of Yverdon, close to the lake of Neufchatel, 1345 feet, which contain bicarbonate of soda and sulphuret of sodium. In the

canton of Freiburg, there are the earthy sulphurous springs of Mont Barri, 2453 feet, and Schwarzsee, 3269 feet. The canton of Valais is very rich in mineral waters, the most important of which are the gypsum thermal springs of Leuk or Louèche, 4351 feet, on the southern declivity of the Gemmi, which were already in use in the twelvth century. Twenty springs of a temperature of 123° issue there in a small area, and at a height of from 4400 to 4500 feet. Another interesting Spa is that of Saxon, on the left bank of the Rhone, which contains a variable amount of iodine, bromine and iron. In the canton of Berne, there are no less than forty-five real mineral waters, amongst which the thermal gypsum springs of Weissenburg, in the neighbourhood of Thun, 2759 feet; the sulphurous gypsum springs of an der Lenk, 3309 feet; the alkaline sulphurous springs of Heustrich, 1940 feet; the sulphurous spring of Leissingen, on the southern shore of the lake of Thun, three miles from Interlaken; the sulphurous gypsum springs of Gurnigel, on the northern declivity of the Stockhorn, 3554 feet; and the alkaline spring of Rosenlaui, 4125 feet, may be mentioned. In the canton of Glarus, there is only one important Spa, that of Stachelberg, 2044 feet, which is an earthy sulphurous spring. In the canton of Appenzell, there are the earthy chalybeates of Heinrichsbad, 2361 feet; and Gonten, 2761 feet; and whey-cures of the greatest excellence, especially in the town of Appenzell, 2404 feet, Heiden, 2424 feet, and Gais, 2875 feet above the sea. The indifferent thermal springs of Pfäffers and Ragatz, in the

canton of St. Gall (Aquae Fabariae), are the most important Spas of Switzerland. Pfäffers, 2108 feet, is situated in a rocky ravine, through which the river Tamina flows on its way to the Rhine; and Ragatz, to which the Pfäffers water is carried by means of an aqueduct, is situated on the declivity of Wartenstein, 1604 feet above the sea, and in the valley of the Rhine.

In Upper Engadin, there are the important acidulous alkalines and chalybeates of St. Moritz, 5464 feet, which are analogous to the springs of Pyrmont, Reinerz and Cudova; and in the Lower Engadin we find the alkaline chalybeates, mofettes and sulphurous springs of Tarasp, 4313 feet. The acidulous chalybeates of St. Bernardin, 5039 feet, two miles below the pass of that name, are also of importance.

The canton of Tessin is very rich in mineral waters, most of which are of the chalybeate group. In the southern part of this canton are the saline muriated sulphurous springs of Stabio, between the hills of Castelletto and Castello, 1197 feet, and which contain sulphuretted hydrogen, and sulphuret of calcium; and the acidulous chalybeates of Rovio and Lugano. At Scerina, in the northern part of the Tessin, there is a vitriol spring called Aqua Rossa, from the yellow-reddish ochre which it deposits, and which contains chiefly sulphate of iron.

In the canton of Basle there is only one important spring, viz. the brine of Schweizerhalle, 840 feet, close to the Rhine, and on the road from Basle to Zurich. In the canton of Aargau there are the muriated gypsum ther-

mals of Baden, which have been renowned for centuries. The valley of Baden is situated between the chains of the Jura, on the banks of the Limmat, 1179 feet above the sea, and twenty-one abundant springs rise there from keuper, clay and gravel. Finally I may mention the saline muriated sulphurous thermals of Schinznach, five miles from Baden, 1057 feet; the bitter-waters of Birmensdorf and Müllingen; and the muriated iodine springs of Wildegg, a small village between Schinznach and Aarau, which are very beneficial in scrofula and allied diseases.

Germany and Austria, with more than 100,000 square miles, possess more than two thousand hot and cold mineral waters, amongst which are many which, in a therapeutical point of view, are unequalled by those of any other country. There is no kind of mineral water of any importance in the treatment of disease which is not to be found in Germany and Austria, where the bathing establishments are also of the most excellent description. Amongst the acidulous chalybeates, in which Germany is especially rich, I may mention the Stahlbrunnen and Weinbrunnen of Schwalbach, in Nassau, on the road between Ems and Wiesbaden, where the springs rise from clay-slate, in a valley on the northern declivity of the Taunus, 900 feet above the sea and 670 feet above the level of the Rhine; the medium temperature of the place being 64° in the months of June, July, and August, and 57°.6 in May and September; the Mühlbrunnen of Altwasser, in Silesia, 1255 feet above the sea, which rises from

red sandstone; the Stahlquelle of Brückenau, near Kissingen, 915 feet; the Fürstenquelle of Imnau, in Hohenzollern, 1241 feet, rising from limestone and anhydrite; the springs of Reinerz, in Silesia, 1720 feet, with a somewhat rough climate; and of Schandau, in Saxony, on the right bank of the Elbe.

Amongst the saline chalybeate springs, the most important are those of Driburg, in Westphalia, 582 feet above the level of the river Weser, in a large valley enclosed by low hills, and rising from conchyliferous limestone; the Stahlquelle of Pyrmont, in Waldeck, in a valley of the Teutoburger Wald, rising from variegated sandstone, 328 feet above the sea, with a medium temperature of 48°.5; the grotto of dogs, which contains carbonic acid, being at the same place; the springs of Bocklet, near Kissingen, 620 feet above the sea; those of Steben, near Hof, rising from clay-slate, 1860 feet; the Josephsquelle of Rippoldsau, in Baden, 1886 feet, rising from mica; the springs of Cudova, in Silesia, ten miles from Reinerz, 1235 feet, and the Franzensquelle, at Franzensbad, near Eger, in Bohemia, 1569 feet, with a mean annual temperature of 45°.

Sulphurous waters are less abundant in Germany than chalybeates. The most important amongst the former are the sulphurous thermals of Aix-la-Chapelle, rising from between transition limestone and clay-slate, 500 feet above the sea, in a flat valley, in Rhenish Prussia; the mean temperature of the place for the months of June, July and August being 63°; the springs of Borcette, close to Aix-la-Chapelle, rising from trans-

ition limestone; and those of Baden, near Vienna, 672 feet, rising from dolomitic limestone. Amongst the cold sulphurous springs of Germany I will chiefly mention those of Nenndorf, in Electoral Hesse, 220 feet, which rise from lias-limestone; those of Eilsen in Schaumburg Lippe, rising from limestone and slate, 250 feet above the sea; and those of Weilbach, in Nassau, on the western declivity of the Taunus, 420 feet.

Saline and alkaline springs are exceedingly numerous in Germany. Amongst the acidulous alkalines, which contain chiefly carbonic acid and bicarbonate of soda, the following deserve to be noticed: Bilin, near Teplitz, in Bohemia, where the springs rise from mica; Neuenahr, on the Rhine, near Remagen; Geilnau, in Nassau, on the right bank of the Lahn, 337 feet, where the springs rise from clay-slate and greywacke; Fachingen, close to Geilnau, on the left bank of the Lahn; and Giesshübel or Buch-Säuerling, near Carlsbad, where the springs rise between basalt and granite.

The most important alkaline muriated acidulous springs are those of Ems, in Nassau, in the valley of the Lahn, 291 feet above the sea, rising from greywacke; those of Selters, in the valley of the Ems, in Nassau, 800 feet, which have been used since the ninth century; those of Salzbrunn, in Silesia, 120 feet, rising from greywacke and porphyry; and those of Luhatschowitz, in Moravia, rising from blue clay, 666 feet above the sea.

Amongst the alkaline saline springs, which contain chiefly bicarbonate and sulphate of soda, Carlsbad, in

Bohemia, deserves special notice. This Spa celebrated its 500th anniversary in 1858, and the continually increasing number of patients who visit the springs there, gives evidence of the high position it occupies amongst the Spas of Europe. The place is imbedded in a hollow valley of the river Tepel, which is surrounded by mountains on three sides, and only open towards the South and South-West. The mountains consist chiefly of granite, which is mixed with basalt, mica, and hornblende. "The number of thermal springs" (says Professor Seegen, of Carlsbad, in a letter to the author) "which issue at Carlsbad, is very large. There are nine "of them now used for drinking and bathing. Warm "aqueous vapours rise from the cellars of most houses; "and wherever in the course of the river Tepel borings "are made, before many feet of ground have been pene-"trated, new thermal springs immediately spout forth. "All these springs, those which are used as well as those "which are not, have their origin in one large and com-"mon reservoir, which has its bed in the river Tepel. "A number of years ago, on the occasion of the resi-"dence amongst us of M. Berzelius, a minute examination "of this reservoir was made. It was then found to be "roofed by three layers of so-called sprudel-stein, a "lime deposit of the water, which has built this roof "three stories high; they are similar to three watch-"glasses turned with the convexity downwards; the "layers lie one above the other, and are separated from "each other by sprudel-stein-gerüst, which is one or "two feet thick. By means of these stony beams each

"story is divided into several cavities, lying close to each "other, honeycomb-fashion. In many places they com- "municate with each other, and with those of the lower "stories. After the lowest story had been bored through, "a large and violently-agitated reservoir of water was "arrived at, the bottom of which could not be sounded. "In accordance with their common origin, all the springs "of Carlsbad have a similar chemical composition, and "they differ chiefly in temperature, which varies from "117°.5 to 162°.5. The springs which are close to the "bed of the river, and are violently thrown upwards "from their common reservoir, have the highest tem- "perature; those which break through the soil at a dis- "tance from that, and have to make a long subterranean "journey before they come to light, are less warm. The "highest temperature is possessed by the Sprudel, and "the lowest by the Marktbrunnen. The cooler springs "contain traces of carbonic acid, which evaporates in "the hot springs, on account of their high temperature. "This small amount of carbonic acid is the only differ- "ence in the chemical composition of all the springs, in "quality as well as in quantity. The springs are there- "fore spoken of as hot and cool, and not as strong and "weak."

Similar to those of Carlsbad are the springs of Marienbad, 1912 feet, in the north-western part of Bohemia, which rise from granite and slate; and those of Bertrich, 433 feet, near Coblentz, in the valley of the Moselle, which rise from the volcanic soil of the Eifel mountains.

The most important bitter-waters are those of Friedrichshall in the duchy of Saxe-Meiningen, where the water rises from marl, sandstone and gypsum; and those of Saidschütz, Sedlitz, and Püllna, in Bohemia, on the road to Carlsbad and Teplitz, rising from marl which consists of weathered basalt, clinkstone, gypsum and lime.

Amongst the simple muriated springs of Germany, I will mention those of Kissingen, in the valley of the Saale, where the Ragoczy, Pandur, Maxbrunnen and other springs rise from variegated sandstone and conchyliferous limestone; those of Homburg, at the foot of the Taunus, 602 feet, rising from clay which contains iron; those of Wiesbaden, the capital of Nassau, on the southern declivity of the Taunus, rising from slate, 320 feet above the sea, in a valley which is only open towards the South, the medium temperature of the place being 51°; those of Baden, in Baden, on the western declivity of the Black Forest, 616 feet, which rise from granite, the mean annual temperature of the place being 48°; and those of Soden, in Nassau, in a valley on the southern declivity of the Taunus, 437 feet, which rise from slate.

The chief muriated lithia waters are the Fettquelle and Murquelle of Baden, in Baden, and the springs of Dürckheim, in the Palatinate.

Amongst the brines, the springs of Rehme, near Minden, in Westphalia, 166 feet, rising from conchyliferous limestone; those of Nauheim, in Electoral Hesse, 450 feet, with three large "sprudels"; those of Ischl,

in the Austrian Salzkammergut, 1442 feet; those of Achselmannstein in the Bavarian Alps, 1107 feet; those of Wittekind, near Halle, and those of Hall, in the Tyrol, deserve special notice.

The principal iodated and bromated muriated springs are those of Kreuznach, in Rhenish Prussia, 330 feet, which probably derive their constituents from the porphyry of the Haardt mountains; those of Dürckheim, in the Palatinate, 358 feet; those of Hall, in the archduchy of Austria, 1000 feet, rising from the tertiary formation; those of Krankenheil, near Tölz, in Upper Bavaria, at the north-eastern side of the Blomberg, 3452 feet; the Adelheidsquelle, at Heilbrunn, 2400 feet, rising from molasse; the springs of Salzbrunn, near Kempten, and others.

The most renowned earthy springs are those of Wildungen, in Waldeck, rising from clay-slate, and those of Lippspringe, in Westphalia, at the foot of the Teutoburger Wald, 378 feet.

Finally, a few words on the "indifferent thermal" springs of Germany and Austria. The most prominent amongst these are Gastein, 3051 feet, in the duchy of Salzburg, in a narrow valley, enclosed by mountains rising to a height of 10,000 feet. The springs ascend from mica, and the medium temperature of the summer months is 59°. Wildbad, in Würtemberg, is situated in a valley of the Black Forest, 1333 feet, where the springs rise from fissures in the granite. The springs which supply the Roman bath of Tüffer, in Styria, 755 feet, issue from dolomite; those of Landeck, in Si-

lesia, 1378 feet, from mica; those of Schlangenbad, in Nassau, 900 feet, from quartzite; those of Teplitz, in Northern Bohemia, 648 feet, from syenitic porphyry; and those of Warmbrunn, on the northern declivity of the Riesengebirge, 1083 feet, from fissures in coarse-grained granite.

Belgium contains only one mineral water justly renowned throughout the world for its curative powers; this is Spaa, situated in a valley of the Vèse, surrounded by steep mountains, and 1030 feet above the sea. The valley is open towards South and South-West, and the soil consists of clay-slate containing iron.

CHAPTER V.

THE PHYSIOLOGICAL ACTION OF MINERAL WATERS.

In judging of the therapeutical action of the Spas, the mistake is frequently made of merely taking into account the principal constituents of the water, and of determining, from the known medicinal properties of these, the action of a special mineral water in which they predominate. But the influence of any single gas or saline which may be considered the characteristic feature of the water, is generally so modified by the presence of other ingredients, by the quantity of water in which it is dissolved, and by the temperature of the springs, that it is impossible to deduct the curative effects of the mineral waters from the properties of any single constituent, however important it may be. Mineral waters are complex medicines which have a peculiar mixture and temperature, and in which a great variety of solid and gaseous ingredients are intimately blended together. It is therefore evident that the only way to arrive at a satisfactory explanation of the curative effects produced by them, is, to study their action when administered to healthy subjects, and to draw our conclusions from the physiological effects which they invariably cause. In laying down this principle, I do not mean to imply that we should limit the em-

ployment of the waters to such diseases only, in which the Spas, from their physiological effects, appear likely to prove beneficial; as we should then unnecessarily restrict their use. There can be no doubt that we are justified in prescribing them in all cases, in which experience shows them to have been successful. But this does not diminish the importance of physiological researches; it should rather stimulate us, to endeavour, by continued experiments and observation, to bring both physiology and therapeutics more and more in accordance with each other.

It is only quite recently that such researches as I have just alluded to, have been undertaken, and there are only a few mineral waters, the exact physiological effects of which are somewhat accurately known. Investigations of this nature should be chiefly directed to the quantity and condition of the faeces, the quantity, specific gravity and composition of the urine, the rate of pulsation and respiration, the amount of carbonic acid expired, the animal temperature, and the weight of the body before, during, and after, the use of the mineral waters.

Observations of this kind are extremely laborious, especially as they must be continued for a considerable period, if the results given by them are to be accepted without reserve. Dr Edward Smith has, indeed, shown* that there are certain daily, seasonal, and other cyclical changes in the human system, which, if not

* Health and disease &c. London 1861.

taken into consideration, would greatly affect the results that might be obtained by such experiments. According to Dr Smith, great variations exist in the amount of urea evolved, not only by different persons in middle life, but also by the same person, within a few days; besides which there is a progressive increase in it as the spring advances, and throughout the summer, until the autumn, when the amount nearly corresponds to that evolved during the winter; the average daily quantity of urea from May to October being 570 grains, and from November to April only 480 grains. In old age the amount of urea decreases both absolutely and relatively to the weight of the body, so that whilst the daily excretion of urea to each thousand parts of body-weight is 9.5 grains at eighteen years of age, and 7.87 at thirty-one years, it falls to 5 grains at sixty-five years. Similar variations take place in the rate of pulsation and respiration, the weight of the body, the evolution of carbonic acid, and the elimination of faeces, all of which have to be carefully considered in experimenting upon the influence exercised by mineral waters on the general metamorphosis of matter in the human system. Independently of this, however, Professor Radicke, of Bonn, has shown* that the ordinary mode of calculating averages, is apt to lead to great errors, and that more exact methods of calculation must be used if anything ap-

* Die Bedeutung und der Werth arithmetischer Mittel &c. Archiv für physiologische Heilkunde, 1858, p. 145.

proaching mathematical certainty is to be obtained by physiological inquiries.

With this reserve, I now proceed to state the facts which are at present known concerning the action of ordinary water and of mineral waters in the human body.

I. ORDINARY WATER.

Water is contained in the blood, and almost all the tissues of the human body. It is of the greatest importance for the processes of absorption, nutrition, secretion, excretion, and animal temperature; all of which undergo very considerable modifications, according as the quantity of liquid food taken is small or large, and its temperature low or high.

When water is introduced into the intestines, it is rapidly absorbed, especially if the amount taken is large and it contains only a small amount of salines. "If" (says Professor Liebig) "a tumbler of about four ounces "of ordinary water, which is poorer in salines than the "blood, is taken every ten minutes, before breakfast, a "quantity of coloured urine will be discharged after the "second tumbler, which nearly corresponds to the quan-"tity of water taken in the first tumbler; and if twenty "tumblersful are taken one after the other, there may "be nineteen discharges of urine, which at last becomes "almost colourless, and then contains hardly more sa-"lines than the water which was drunk. If the same "experiment be made with water to which about as

"much tablesalt is added as is contained in the blood, "the excretion of urine is not increased. It is scarcely "possible to take more than three tumblersful of such "water; and a sensation of fulness, heaviness and op- "pression in the stomach are sure signs, that water con- "taining the same amount of salines as the blood, re- "quires far more time to become absorbed than ordinary "water. Finally, if water is taken which contains a "larger amount of salines than the blood, the contrary "of absorption, viz. purging, is produced."

The absorption of water is retarded if the blood-vessels are much distended, and when evaporation and perspiration are impeded, as is the case during a bath. If, on the contrary, there is profuse perspiration, absorption is accelerated.

The quantity of water which may be absorbed by the intestines in a given time, is very large. Cases of diabetes are on record, in which upwards of two hundred pounds of urine have been passed during twenty-four hours. Willis relates the case of a man who drank two large bucketsful of water every day; and Heider mentions another, where ninety tumblersful of the Kreuzbrunnen of Marienbad were taken during the twenty-four hours. In certain hydropathic establishments, even at the present day, some patients are ill-advised enough to drink upwards of twenty pounds of water daily. The consequence of immoderate water drinking is a morbid alteration of the blood-globules, that is, of the most important constituents of the blood.

Numerous experiments made by Chossat, Becquerel,

Thomson, Vogel, Lehmann, Nasse, Böcker, Genth and Mosler, have established the fact that by drinking water the general metamorphosis of matter is accelerated. The urinary water voided is considerably augmented, although the surplus is not proportionate to the surplus water taken. Regarding the solid constituents of the urine, the excretion of urea is very much increased. Uric acid, on the contrary, is diminished, or even entirely disappears from the urine; but if much water is lost by perspiration, and little taken internally, uric acid is, on the other hand, increased. The evolution of phosphates, sulphates and chlorides is also augmented, if much water is drunk.

Dr Mosler has found * that, as regards age, sex and constitution, the same quantity of water had a much more considerable and lasting effect in boys and girls, than in adult males. If water was administered for a somewhat lengthened period to persons of feeble constitution, the metamorphosis was in them increased to a greater degree than was the case in persons of vigorous constitution; and febrile symptoms sometimes set in, which, in a few instances, were of a threatening character. The temperature of the atmosphere and of the water drunk had also a certain influence. If the air was warm, and exercise was at the same time taken, the metamorphosis was still further accelerated. Warm water proved more efficacious than cold, and its action

* Untersuchungen über den Einfluss des innerlichen Gebrauches &c. Gekrönte Preisschrift. Göttingen 1857.

also differed according as the several doses of water were drunk at long intervals or in rapid succession.

In cases where the increased appetite was indulged by a more abundant administration of food, the expense of the system was compensated, and therefore the long-continued use of water did not make such inroads upon the constitution as was the case if the food was not increased; the weight of the body was also not so much diminished under such circumstances. In some instances the action of the water was chiefly diuretic, in others it was more diaphoretic. As regards the intestines, in the majority of cases only a very trifling quantity of water was eliminated by them; but in one boy and two girls, a large amount of water taken caused profuse diarrhoea, which was also observed in a few adult males, after a long continued use of the water.

Dr Genth has observed that, if 4000 cubic centimètres of water were drunk during twenty-four hours, the animal temperature was lowered, the pulse retarded, and the number of inspirations diminished.

The disturbances observed by Dr Mosler after withdrawing liquid food, were very striking, and ensued more rapidly in persons in whom the metamorphosis was comparatively more energetic than in others; if the solid food which was given, contained only a small amount of water; if exercise was taken, and if, in consequence of previous indisposition, there was no great power of resistance to morbid influences. In every case the secretions and excretions were diminished, especially

the excretion of urine, which, although its specific gravity was considerably increased, was nevertheless found to contain a much smaller amount of solid constituents than the quantity of urine which had been previously discharged. The urea was chiefly diminished; after that came the chloride of sodium, phosphoric acid, and sulphuric acid. Effete matter was, therefore, retained in the blood, in consequence of a diminished action of the kidneys; and to this the morbid symptoms which were observed, were no doubt to be ascribed. The excretion by the skin and the lungs was also much diminished; costiveness, loss of appetite, and a dry tongue were complained of — symptoms evidently due to a deficiency in the secretion of the mucous membrane of the mouth, the stomach, and the intestines.

The *temperature* of the water which is drunk has an important bearing upon its action in the system. Cold water abstracts a certain amount of caloric from the body; it excites a sensation of cold in the mouth, gullet, and stomach, effects a more powerful peristaltic motion of the stomach and the intestines, increases the appetite, and retards the heart's action. It disturbs the functions of the stomach if this is weak, digestion being intimately connected with a somewhat high temperature; for the gastric juice does not dissolve albumen, nor does the pancreatic juice transform amylum into sugar, at a low degree of temperature. Snow-eating does not quench the thirst, but rather increases it, probably because by the contact of snow with the

mucous membrane of the mouth and gullet, inflammation of these parts, and consequently dryness and a feeling of thirst, are produced. If the water is intensely cold, or if ice is eaten, the peristaltic action of the stomach and intestines is no longer increased, but altogether stopped for some time, the sensibility of the nerves being benumbed by the cold; hence the power of ice internally administered, to arrest vomiting.

If the water taken is warm or hot, the animal temperature is increased, the capillaries of the stomach are dilated , and perspiration is induced. Water of a high temperature does not excite the peristaltic movements of the intestines; and for this reason certain mineral waters which, when taken cold, produce purging, have no such effect, if hot.

Cold baths.

Cold acts as a stimulus upon the capillary vessels of the skin which contracts under its influence; the follicles thus become more prominent, and cutis anserina is produced. This contraction is strongest in the tunica dartos. If the cold is very intense, and its action somewhat prolonged, the capillary circulation may be entirely stopped. This can be shown by applying ice to the foot of a frog; and it is also evidenced by the hands turning purple in cold weather. At the same time the internal organs are congested, in consequence of which head-ache, oppression in the epigastrium, difficulty of breathing, sleepiness, vertigo, tottering gait, and even paralysis may be caused.

Bégin, who took a number of cold baths, of a temperature varying from 36° to 43°, during which he was continually swimming, has described the symptoms caused thereby, as follows: — At the moment of plunging into the water, a sensation as if the blood was rushing towards the large cavities is produced; the respiration becomes panting, interrupted and very rapid — the skin sallow — the pulse contracted, small and hard — all the tissues are rigid — a sort of general spasm is induced, and regular movements are almost impossible. After two or three minutes these painful symptoms subside; the respiration becomes more free, the chest expands, the movements are easier, the skin becomes warm, the whole surface of the body glows, the pulse is full, large, firm and regular, and a delicious sensation of well-being and power pervades the whole frame. This state continues for fifteen or twenty minutes, when another chill is felt. If one does not then leave the water, rigors and a general trembling ensue; the movements become difficult, so that there is danger of drowning; and for this reason a complete return of the chill should not be waited for. If one now leaves the water, the contact of the skin with the air causes a feeling of warmth, in spite of the currents of air, and the evaporation of moisture from the surface of the body. The skin is almost insensible to touch, so that the towels by which the water is wiped off, are not felt, and the epidermis is sometimes rubbed off in large patches without any pain being caused.

M. Rostan, who has also taken very cold baths,

but, while in the water, avoided movements as far as possible, has given a somewhat different description of the effects produced thereby. After having taken a walk, he bathed in the Seine, the water being at 41°. Immediately after immersion, he felt a very strong chill, general tremor, trembling of the lower jaw, headache and rigidity of the limbs. On making a few movements, the effects of the cold became stronger, probably because fresh layers of water came in contact with the skin. After a few minutes, he felt violent headache, epigastralgia, intense pain in. and spasms of, all the muscles. He at last became so benumbed that he was obliged to get out of the river, after having been it for five or six minutes. On leaving the water, the rigors continued; the bulk of the limbs seemed to have considerably shrunk; the skin was covered with violet spots, the eyes appeared hollow, the nose pointed, the lips blue, the face sallow, the ears livid, and the lower jaw trembled. The heart beat violently, the pulse at the wrist was small and frequent, the respiration accelerated and impeded, and oppression was felt on the chest. The taste was bitter and pappy, the epigastrium painful, and the appetite gone. The urine was pale and copious, the movements were difficult, and fulness was felt in the head. After having dried and clothed himself, he felt better; nevertheless most of the symptoms mentioned, especially the fulness in the head, the loss of appetite, and the numbness in the limbs, persisted for the greater part of the day. Towards evening a strong reaction set in, and pungent heat was felt in

the night, coupled with sleeplessness and great excitement.

Lersch has given the following rationale of the action of the cold bath upon the human body:—One of the first symptoms caused, is the contraction of the capillary vessels of the skin, whereby the extent of surface exposed to the cold becomes diminished, and evaporation and radiation from the skin are, to a certain degree, prevented. Thus the blood is in some measure protected from the action of the cold; the heat of the internal organs is increased, and the heart's action fully kept up. At the same time deep inspirations are made, whereby more oxygen is drawn into the lungs, and the activity of the heart is increased; but the rate of pulsation soon becomes retarded, and less blood is consequently brought into contact with the cold skin. After some time the contraction of the capillary vessels ceases, and they become fuller; but the blood does not circulate in them, and the cold is therefore not communicated to the whole of the circulating liquid Moreover, the blood is the less refrigerated the more its temperature has been previously lowered. When the obstruction in the capillaries has become considerable; when the blood is overcharged with carbonic acid, and the skin, the nerves and the muscles are thereby endangered, the pulse again becomes faster and stronger; and as deep inspirations continue to be made, the large veins become more rapidly emptied, and the oxidation of tissue and the production of heat are augmented. After a while the internal organs be-

come colder, whereupon the heart beats still faster, the impulse being now communicated to the blood in the capillary vessels, so that the circulation in them is partially restored. The movements of the muscles thus become more free, and the peripheral ends of the sentient nerves obtain a fresh supply of heat from within, whereby a general feeling of warmth is produced, which is greatly facilitated by the nerves becoming gradually accustomed, and therefore less sensitive, to the cold. But if at this period, the duration of which differs in different persons, cold is still allowed to act on the body, the heart's action becomes weakened, the circulation in the capillary vessels is again interrupted, and a second general tremor sets in*.

Dr Esmarch, of Kiel, has investigated the influence of the plunge sea-bath upon the action of the heart. He found that, in the course of his walk to the beach, the pulse rose 20 to 24 beats, and in the bath it rose about ten beats higher. During the ten minutes immediately succeeding the bath, the pulse fell from ten to twenty beats; and on arriving home, the rate of the pulse was less than it had been on arriving at the beach. Other experiments made by Poitevin and Currie show, that cold bathing causes, on the whole, a diminution of the heart's action; while Virchow found the rate of the pulse sometimes lessened, and sometimes increased by the cold bath. Macard came to the

* Einleitung in die Mineralquellenlehre. Erlangen 1855. Vol. I. p. 491.

conclusion, that all baths below 95° have a sedative influence upon the heart; and that this is the more strongly marked in proportion to the length of the bath, and the velocity of the pulse before taking it. It would therefore appear that a lowering of the temperature of the blood has a tranquillising influence upon the heart.

Animal heat is also considerably affected by cold bathing. Every cold bath withdraws from the body a certain amount of caloric, which is the more considerable, the greater the difference between the temperature of the water and of the skin. Esmarch's observations in the seabath of Düsternbrook, near Kiel, have shown that, during the walk to the bath, in cold weather, the temperature sank 1°.8 to 3°.06, and during the bath about 1°.08 more; but immediately after the bath, it again rose from 1°.8 to 3°.6.

Professor Virchow has experimented upon the same subject in the sea-bath of Misdroy, where he took a series of baths from the 17th to the 29th of August, and from the 8th to the 13th of September*. He noted the temperature in the house, in the open air, in the bathing machine, that of the sea itself, and the amount of exercise taken during the bath; the temperature of the mouth and the hand, before and after bathing, the duration of the bath, food, occupation &c. The temperature of the sea varied 5°.7, and that of the air 9°.

* Physiologische Bemerkungen über das Seebaden, mit besonderer Rücksicht auf Misdroy. Virchow's Archiv Vol. XV. p. 70.

On two occasions he made the observations on animal heat in the arm-pit, but otherwise in the mouth and the palm of the hand. The temperature in the mouth was generally 97°.3; the bath invariably caused the heat to fall from 1° to 3°.6, notwithstanding the exertions he made while in the sea, and in walking to the beach. The longer he remained in the water, the more the temperature was lowered. In the palm of the hand it fell on the average to 57°.9. As regards cooling, the air was found to have a more powerful influence than the water. Half an hour after taking the bath, the temperature of the mouth rose above what it was on entering the bath, and continued some degrees above its normal standard during the middle of the day and the afternoon, whilst in the evening it fell again, but not to that degree at which it had been in the morning. In the peripheral parts of the body, such as the hands &c., the normal temperature was not regained until two or three hours had elapsed after taking the bath.

Professor Hoppe has observed that, if a dog was placed in a bath of 52° to 59°, the temperature in the rectum of the animal fell during the first minute from 1°.6 to 2°.25. In a dog who was placed up to the neck in a bath of 32°, the temperature fell 3°.6 after two minutes; and after five minutes and a half, it had fallen 5°.8 more. He also noticed that, if dogs were immersed in cold water and again taken out of it, the heat rose as long as the skin remained wet; but that it fell, after the skin had become quite dry.

Dr Liebermeister, of Tübingen, has found that, if a cold bath was taken for a moderate time, the heat in the arm-pit was not diminished. He made three experiments with sea-baths, and nine with a cold douche of from 35°.6 to 68°. Immediately after undressing, he noticed a slight increase in the temperature. During the bath he remarked either no variation, or a slight increase of heat; and after he had again dressed, the temperature appeared lessened. In two experiments, where the cold douche was applied after a hot bath, the heat fell 1°.8. Dr Liebermeister is inclined to think, that the results obtained by Virchow are due to his having determined the temperature, not in the arm-pit, but in the mouth, which latter is not so well suited for such experiments as the former*. Currie has come to the conclusion, that in a cold bath of 39° to 43°, the heat generated in the body is ten times the amount of that produced under ordinary circumstances.

As to the effects of cold general baths upon the excretions, very little is at present known. They seem to temporarily increase the quantity of urinary water, and the solids, especially of urea; and to diminish the excretion by the skin and the lungs. At the same time, the acidity of the urine is decidedly lessened.

Cold baths interrupt the noxious action of heat, which enfeebles the muscles, nerves, heart, and intestines; and if taken in a judicious manner, they tend to

* See my paper on "Animal temperature", Medical Times and Gazette, October 19, 1861.

increase the appetite, to promote nutrition, respiration, and the oxidation of tissue. They also stimulate the nervous system generally, and under their use the skin becomes firmer, and the hair is not unfrequently found to grow more abundantly.

Where there is little vital power, there is only a limited capability of reaction against cold. Weak persons, therefore, feel uncomfortable after cold bathing, especially if they remain in the water for some time. A cold bath of two or three minutes duration may still be useful and strengthening to such persons; but if it be prolonged beyond that time, indisposition is generally the consequence. Sanctorius has already remarked: "lavacra frigida corpora robusta calefaciunt, debilia refrigerant."

Tepid baths.

The less cold the water used for bathing is, the less considerable is its exciting action; and reaction is consequently retarded and diminished. In tepid water the cooling of the body does not take place suddenly, but is protracted over a longer period. The feeling of cold excited by tepid baths, varies greatly according to the temperature of the atmosphere, and is also different in various parts of the body, such as the feet, the trunk, the arm-pit &c. If the water is only slightly colder than the skin, it is generally felt as warm, as the evaporation from the surface of the body is prevented, whereby a source of cooling is cut off. The action of the bath upon the muscles is also very slight,

as no tremor ensues; nor is the effect produced upon the capillary vessels at all powerful. The pulse is generally somewhat retarded, especially if it was accelerated before the bath. At the same time the number of inspirations is diminished, and sleepiness is induced, probably because the uniform warmth does not excite any striking sensations in the nerves, nor movements in the peripheral muscles.

Dr Lehmann* has investigated the physiological action of warm general baths in a series of experiments which were continued for twenty days, the bath being of half an hour's duration, and having a temperature of 89°. He found that the excretion of urinary water was at first increased (from 1 to 3.9) but it afterwards again diminished, so that the amount for the twenty-four hours remained unaltered. These results have been confirmed by Nasse and Poulet. M. Homolle has also noticed, that the acidity of the urine is diminished after all baths, with the exception of such as are very hot**.

Hot baths.

M. Rostan who has taken baths of a temperature varying from 99° to 115°, has described their effects as follows: —on entering the water, he felt a tremor similar to that which is perceived on first entering a cold bath. After this had ceased, a great and general heat was felt,

* Die Sooltherme zu Bad Oeynhausen. Göttingen 1856.
** L'Union médicale 1853, p. 177.

the pulse became stronger and more frequent, and rose to 117 beats in the second. After half an hour, the respiration became accelerated and impeded, the mouth dry, the thirst violent, the face dark-red and puffed; the eyes appeared prominent and injected; tears flowed freely; the carotid and temporal arteries pulsated violently; the head felt heavy and giddy, and a troublesome sensation of excessive heat rendered it necessary that cold water should be poured over the head. This gave immediate relief; but if it was omitted, his anxiety became so great that he was obliged to quit the bath. The intellectual faculties were hebetated, and somnolence was induced. The bulk of the body was considerably increased, and copious perspiration flowed from the forehead and the whole surface of the body. The muscles became rigid, and the movements were impeded and troublesome. After the bath he felt exceedingly weary, and he preferred the standing posture. The lower extremities then seemed red and more swollen than the other parts of the body. Soon afterwards the head again felt clear, but the pulse remained full and frequent, the perspiration abundant, and the feeling of fatigue only ceased after a night's rest. There was little appetite during the remainder of the day, and the excretion of the urine was diminished.

The description given of hot baths by M. Loude tallies with the foregoing. He says:—on entering the hot bath, one perceives a pungent and troublesome heat; the skin is, as it were, affected by a spasm, and

by contractions analogous to those perceived in the cold bath. This spasm soon disappears; the skin and the subjacent organs become red and swollen, the blood is diluted (?), the heart contracts rapidly, the carotid and temporal arteries beat violently, the face is red, the eyes are injected, and the respiration rapid and impeded. About ten minutes after entering the bath, this storm abates; perspiration flows from the face, and effects a powerful, although by no means sufficient, cooling. He once took, in the presence of several persons, a bath of 113°, and after a strong venaesection, he had the temperature even increased to 118°.4. The effects of this were a peripheral spasm on entering the water, acceleration of the pulse, and violent perspiration. When he left the bath, the loss of blood, the perspiration, and the heat, caused him to faint, a sign that the artificial plethora had been replaced by depletion of the brain.

The following symptoms are observed in persons who stop for a short time in the large bath of Mont-d'or which has a temperature of 114°.5: — they feel a powerful sensation of heat; the pulse becomes full and rapid, and the respiration accelerated; the face is red and covered with perspiration, the conjunctiva is injected, the lips are turgid; there is general perspiration and sopor, which may become dangerous if the bath is prolonged. On leaving it, the skin appears red and unequally tumefied; there is fulness of the head, the gait is tottering, the perspiration continues, and the whole surface of the body is covered with a

fatty film. After the patient is placed in his bed, all these symptoms gradually disappear, and a copious and inodorous perspiration sets in, after which a feeling of buoyancy and vigour ensues, which lasts for the rest of the day.

If persons bathe in the hottest spring of Balaruc (116° to 122°), the pulse and the respiration become much accelerated, and the face is covered with perspiration. If they remain in it for more than five minutes, ringing in the ears, vertigo and obscuration of sight, fainting, and in plethoric persons even apoplexy, may be the result.

In Lavey, in Switzerland, where baths of a temperature of 113° and upwards have sometimes been given, fainting, epileptic fits, and congestion of the spinal cord, have been known to follow.

M. Minnich has observed, that the hot baths of Baden, in Switzerland, which have a temperature of 97° and upwards, produce sexual excitement, fulness in the head, vertigo, sleepiness, thirst, accelerated and irregular pulse, dimness of sight, vomiting and fainting. After the bath, there is sleeplessness, or sleep disturbed by dreams; and after the sleep, heaviness in the head, head-ache, indisposition, copious perspiration, gastric symptoms, and constipation. In one case, after a prolonged hot bath, he observed amblyopia, which only yielded to very active and protracted treatment.

Regarding animal heat, during and after baths which have a higher temperature than the body, Messrs. Currie and Liebermeister have found, that at first there is

a contraction of the muscular fibres of the bloodvessels, and a decrease of temperature; afterwards the muscular fibres become relaxed, the circulation in the skin is promoted, perspiration induced, and the animal temperature augmented. Professor Hoppe remarked that, if a dog was placed for three minutes in water of 118°, the temperature in the rectum rose from 101°.6 to 106°.5. This increase, however, did not continue; after five minutes the temperature fell again, and fifty minutes after the bath, it was 99°.5, that is, 2°.1 below the original temperature. Liebermeister states that in a bath of 99° to 100°, the production of heat is not essentially different from that under ordinary circumstances.

The effects of bathing also vary considerably according to the duration of the baths, and the longer or shorter intervals at which they are repeated. In some of the Swiss Spas, such as Leuk, Stachelberg, Schinznach, and others, the Physicians frequently advise patients to continue bathing until an eruption appears in the skin. In Leuk, where many patients remain in the water from four a. m. to ten a. m., and again from two until five p. m., the following symptoms are generally observed: — The water at first renders the skin soft and hyperaemic, and the parts immersed have a soapy feel; but after the patient has been in it for some time, the skin becomes dry and rough. Between the fifth and twelvth day, a feeling of fatigue comes on; old sufferings are renewed, scars become painful, and ulcers secrete more abundantly; there is also loss of

appetite, fulness in the head and stomach, sickness, disturbed sleep, and a quick pulse. An eruption then breaks out, after which the unpleasant symptoms usually disappear. In some cases there is also profuse perspiration and diarrhoea, and the urine becomes turbid and forms deposits; while in other instances no unpleasant symptoms whatever precede the eruption. The rash at first appears on the elbows and knees, and from these spreads to the arms, legs, and the whole body, with the exception of the hands, the soles of the feet, and the face, which are scarcely ever affected. It generally runs through four stages, viz. incubation, eruption, full development, and desquamation. It sometimes resembles erysipelas, in other cases erythema, or the scarlet rash; or small thickly studded papulae are formed. If the air is warm, the outbreak as well as the regular course and the termination of the rash, are favoured. It is said that this disappears only if the baths are persevered in; but that if they are discontinued, the eruption becomes very obstinate, and lasts for a long time. A burning sensation is then perceived, and rhagades and prurigo may even be the consequence. If the eruption is very considerable, a yellow and tenacious secretion is formed, which causes the linen to adhere firmly to the skin; and in order to get it off, it is necessary to moisten it with the thermal water. Sometimes itching, burning, rigors, heat and perspiration accompany the rash, and the feet become oedematous; if such is the case, the patient must remain either in bed or on the sofa, when he is not in the bath,

to which he has to be carried, as walking is then painful. On first entering the bath, under these circumstances, a burning sensation is perceived; but after a few moments a feeling of relief ensues. If the eruption is unusually severe, the patient is only allowed to bathe in the morning, and not in the afternoon.

The effects of the baths of Stachelberg resemble those produced by the thermal waters of Leuk. At Stachelberg, the patients also bathe twice a day; they commence with one hour in the morning, and half an hour in the evening; the bath is then gradually prolonged to two hours and a half in the morning, and two hours in the evening. After the bath, the patient remains in bed for an hour. During the first week no unpleasant symptoms are perceived; but after eight or ten days have elapsed, thirst, loss of appetite, coated tongue, weariness, indisposition, fulness in the head, heat, and acceleration of the pulse ensue. Between the twelvth and fourteenth day, the rash breaks out, generally on the nape of the neck, the back, the arms and the thighs first; from these parts it spreads over the chest, the abdomen, and the whole body. It generally resembles the scarlet rash, but sometimes miliary vesicles are produced. It rarely happens that the rash appears simultaneously on the whole of the body; and the face and the hands are very seldom affected by it. It appears most striking immediately after the patient has left the bath, and while he is in bed, when it resembles genuine scarlatina. The eruption generally lasts from six to eight days, and a burning sen-

sation is complained of during this time. After that, the skin assumes a dirty-grey colour, which indicates the commencement of desquamation; this period generally lasts from eight to ten days, during which the duration of the bath has to be shortened, and care must be taken to avoid the outbreak of a fresh rash. If no rash has appeared after three weeks' bathing, it usually does so after the application of six or eight cuppings, by which the skin is still further stimulated.

Although no doubt obstinate diseases of the skin and other affections of the system have been improved and even cured by this mode of bathing, it may, in my opinion, be almost entirely dispensed with; and it will be only in exceptional cases, and after other methods of treatment have been found unavailing, that a conscientious Physician will consent to advise the adoption of this plan of treating disease.

Hip-baths.

In these baths which are generally taken cold, the water only covers the upper parts of the thighs, and the body to just above the pelvis; that is, about one fifth of the whole surface of the body. They act chiefly upon the perinaeum, the urinary and sexual organs, the rectum, the lower part of the spinal cord, and the large vessels and nerves of the lower extremities. If the water used is very cold, it stimulates the action of the bowels, alters the abdominal circulation, and withdraws a certain amount of caloric from the body. If the water is chilled, it retards the râte of the pulse;

if tepid, it diminishes local irritability; and if warm, it induces hyperaemia of the pelvic organs.

The action of hip-baths has been chiefly studied by Messrs Lehmann, Lampe, H. Johnson, Petri, and Böcker. Dr Lehmann* first determined, on eight days, the secretions and excretions of his own body, for six hours during which he took no food; special attention being paid to the weight of the body, the quantity of the urine, the faeces, and the insensible perspiration by the skin and lungs. On eight other days, he took one or two cold hip-baths during the six hours, and again noted the loss of body-weight, and the amount of urine, faeces, and insensible perspiration. On comparing the results of the two series, he found that, on the days when the hip-baths were taken, the excretion of urinary water and of the solid constituents of the urine, especially the urea and the chloride of sodium, was augmented. If he remained in a hip-bath of 48° for a quarter of an hour, the temperature of the perinaeum fell 12°.7. In a hip-bath of 50°, and of a quarter of an hour's duration, forty-five pounds of water were, at the expense of the system, heated 21°.9. At the same time the pulse became slower and the respiration remained either unaltered or was slightly accelerated, especially during the first five or ten minutes. Although these experiments were performed with great care, they are open to the objection that they were not made on consecutive days, but were

* Archiv des Vereins etc. Vol. I. p. 521.

scattered over a period of nearly four months; besides which their number is not sufficiently large for allowing an average to be drawn; and finally, they were only made on one person, so that their results only hold good for that person individually, but not for others. The degree of susceptibility to the action of such baths seems, indeed, to be exceedingly different in different persons; and while they act as excitants in some, they may have a depressing effect on others. Dr Böcker, of Bonn, found that hip-baths, at a temperature of 50° to 63°, produced, within a period of three hours after taking them, no effect whatever upon the quantity of urinary water and the solid constituents of the urine. The rate of the pulse was not diminished, on the contrary, it increased on his first entering the bath; but it quickly subsided to its ordinary velocity. Other experiments made by Lampe, H. Johnson, and Petri, would seem to show that the cold hip-bath generally retards the pulse. The circumstance that idiosyncrasy of the person experimented upon, should have such an important bearing upon the effects of these baths, is a serious impediment to our arriving at a satisfactory conclusion respecting their action generally.

Dr Lehmann has also investigated the action of warm hip-baths*. He determined the amount of urine excreted every hour, and found that by hip-baths of 65° to 70°, and by such of 88° to 99°, the urinary water and the solid constituents of the urine were consider-

* Archiv des Vereins etc. Bd. II. p. 1.

ably augmented; but that by baths of a temperature varying from 70° to 88°, no such effect was produced. These results seem so extraordinary that fresh researches are required before they can be implicitly adopted.

Cold shower-baths.

Dr Sieveking has investigated the influence of the cold shower-bath on the action of the heart*. He found in the mean of a series of twenty observations, that the pulse was 67.90 before, and 61.33 after, a cold shower-bath; which was therefore shown to exercise a directly sedative influence upon the function of the heart. Immediately after the bath active exercise was taken, but this did not prove sufficient to raise the pulse again to its normal standard.

Dr Böcker has likewise investigated this subject and has arrived at the same negative conclusions which were yielded by almost all the researches of this industrious observer. He found that, within three hours after taking shower-baths of seven minutes' duration, in which the water had a temperature of 52°, and a fall of forty-six feet, neither the weight of the body, nor the quantity and composition of the urine were in any way altered.

The question now remains to be discussed, whether

* Ueber den Einfluss des kalten Sturzbades etc. Archiv für Heilkunde, Vol. II. p. 1.

or not, water is absorbed by the skin during a bath. It is exceedingly difficult to come to a satisfactory conclusion on this apparently simple point, since the mere comparison of the weight of the body before and after the bath, gives by no means sufficient data for deciding it. If we find the weight of the body increased after a bath, this is not necessarily due to a certain quantity of water having been absorbed, but may be the consequence of a lessened metamorphosis of matter, and of a mechanical adhesion of water to the surface of the body. We know that the weight of the body is continually decreasing, effete substances being eliminated by the skin, the lungs, and other organs; and this loss of substance considerably varies with the influences to which the system is subjected. Moreover, the cuticle and the hair are very hygroscopic, and may retain water without this having been actually absorbed.

It was formerly believed, that the experience said to have been made by persons, who after ship-wrecks or other accidents, could not obtain water fit for drinking and quenched their thirst by bathing, proved the absorption of water by the skin. But even if such narratives had a more solid foundation than most of them actually possess, the experience made under such circumstances would only prove that water may be absorbed if there is a considerable deficiency of it in the system; but not that it is absorbed by the skin if the body is in its ordinary condition.

The experiments made on this point by the older

observers must be received with considerable diffidence. We cannot attach any value to the assertion of Wetzler, that in a bath of one hour's duration, four pounds of water were absorbed. The same may be said of the observations of Kathlor who found, that a person who remained for an hour in a bath at 104°, gained from two to six pounds in weight; of Falconer, who put the average quantity of water absorbed at one pound; and of Berthold, who noticed, after a bath of fifteen minutes and 81°.5, an increase of 2700 grains in the weight of the body; after a bath of three quarters of an hour, an increase of 6600 grains; and after a bath of a whole hour an increase of even 7650 grains. Messrs Séguin and Cruikshank have, on the other hand, come to the conclusion, that the weight of the body is diminished after the bath.

Amongst the more recent experiments on this subject, those of Lehmann, Kletzinsky, Falck, Poulet and Homolle, are the most important. Lehmann found that, if he prepared two baths containing an equal quantity of water, and used one of them, then wiped the body with a weighed towel which was again weighed immediately after having been used, and finally again weighed both baths, the difference between the two amounted to 116 grains out of fifty pounds of water; that is, a quantity equal to about $^1/_{3333}$d of the entire bath. Lehmann was led to the conclusion that in a common warm water-bath, no water is absorbed by the skin; and this opinion is shared by most other contemporaneous inquirers into the subject. Dr Mosler

has even found that, after a warm bath of an hour's duration, the weight of the body was diminished by 9000 grains; and after two hot baths, this decrease even amounted to 14525, and 13950 grains; probably in consequence of a more considerable loss of carbonic acid and water through the lungs. Poulet has satisfied himself that water is not absorbed by the skin; but M. Durian believes that, independently of the hygroscopic swelling of the integuments, there may be actual absorption of water under certain circumstances. Quite recently Dr Lehmann has undertaken a fresh series of experiments in order to settle this question, and has come to the conclusion that with the means of investigation at present at our disposal, it is impossible to ascertain whether water is absorbed by the skin or not*.

II. MINERAL WATERS.

All mineral waters have one action in common, which is derived from the influence of the water itself; but in other respects their effects are widely different. It is, therefore, necessary, to examine the physiological effects of the different groups of mineral waters separately.

1. ALKALINE ACIDULOUS SPRINGS.

The chief contents of these waters, as representative

* Ueber die Diffusion durch die Haut im Bade. Virchow's Archiv. 1862.

of which I have named those of Vichy, are carbonic acid and bicarbonate of soda; and before entering into the effects of the Vichy water, and other similarly constituted Spas, in the system, I will give a short survey of the physiological action of the two most important ingredients contained in them.

Carbonic acid bound to alkalies is found in the blood and all other liquids of the human body. If inhaled in any considerable quantity, this gas extinguishes animal life in a short time; a mixture of forty parts of oxygen, forty-five parts of nitrogen, and fifteen parts of carbonic acid, being sufficient to cause death. If carbonic acid is mixed with a more considerable amount of oxygen, the poisoning is retarded. Women, children, and delicate persons generally, are more easily affected by this gas than adult males, and torpid subjects. Animal life is extinguished partly because that quantity of carbonic acid, which is contained in the blood and which ought to be expired, is retained in it, and partly because a fresh supply of carbonic acid is at the same time introduced into the system. Respiration, evolution of animal heat, excretion of effete matter, and the functions of the nervous system generally, are thus impeded or even rendered impossible.

The following are the remote effects produced by the absorption of poisonous doses of carbonic acid gas: — at first a sensation of heat all over the body is produced. The forehead is covered with perspiration, and the complexion ruddy. The heat soon becomes troublesome, the face has either an intensely

red, or a ghastly appearance; and vertigo, tottering gait, asphyxia, and death follow. The remote effects of carbonic acid are more powerful if it is inhaled by the lungs; and less so, if introduced into the stomach and intestines, or when absorbed by the skin. The gas also produces very striking local symptoms, when applied to the different organs of the human body.

Concerning the respiratory organs, we find that pure carbonic acid cannot be inhaled, because the glottis is spasmodically closed by it. If diluted with air, it causes dyspnoea, and a sensation of heat in the mucous membrane of the larynx, the trachea and the lungs; and the respiratory movements are either accelerated or suppressed. By reflex action cough is caused, and the secretion of mucus in the air-passages is increased. In a person who died by inhaling the gas in the Grotto of Dogs, at Pyrmont, the mucous membrane of the respiratory tract appeared intensely reddened.

If applied locally to the eye, carbonic acid produces a sensation of pricking and burning in the conjunctiva, which becomes injected, and the eye is spasmodically closed. Tears flow freely, and the secretion of palpebral mucus is also increased; but if the excitation is prolonged, or the gas not sufficiently diluted with air, both the secretions mentioned may be entirely suppressed. Other symptoms are photophobia, an increased mobility of the iris, and various disturbances of vision.

A douche of carbonic acid, directed to the membrana tympani, excites tinnitus aurium, and noises in

the ear; either from congestion, or in consequence of a contraction of the muscles of the internal ear. The sense of hearing is rendered more acute, the secretion of cerumen is augmented, the external meatus becomes turgid and red, sometimes the hyperaemia spreads to the face, and if the excitation is powerful, general perspiration ensues. Not unfrequently great sleepiness follows this operation; this goes far to show that carbonic acid is absorbed by the drum of the ear, and carried directly to the brain.

Carbonic acid, when applied to the mouth and the gullet, causes an acidulous and astringent taste, an increased flow of saliva, a burning sensation in the uvula, and injection of the root of the tongue. If the douche is strong, loss of taste and a feeling of heaviness in the tongue, is brought about.

If carried to the Eustachian tube, the gas excites a feeling of heat and dryness in this canal. When applied to the nose, it causes tickling and sneezing, and the mucous secretion of the Schneiderian membrane is increased; but the gas does not seem to exercise any specific influence upon the olfactory nerve.

Carbonic acid has also a remarkable effect upon the expulsive powers of the uterus, and by the application of the gas douche to the abdomen, menstrual and hemorrhoidal bleedings, and in pregnant women abortion, may be induced.

When swallowed without water, which it is not easy to do, carbonic acid, according to Küster, promotes the

appetite, and the peristaltic motion of the stomach and the intestines.

The skin is also considerably affected by it. If a dry bath of this gas is given, the most constant symptom produced, is a feeling of heat in the skin, especially of the generative organs, the abdomen, and the lower extremities. The capillary vessels become hyperaemic; the sentient nerves of the skin are irritated; pricking and formication are caused, and by a too prolonged use of the gas-bath, inflammation of the skin may, in delicate persons, be the result. The experiments of Autenrieth, Abernethy, and Collard have proved, that carbonic acid is not only absorbed by the lungs, but also by the skin. Collard, after having been immersed for five minutes in a carbonic acid gas-bath, felt fulness in the head, dimness of vision, ringing in the ears, pain in the temples, somnolence, and oppression on the chest. After twenty minutes, he had become so weak that he could no longer hold the tube by which he breathed air. Graefe, on the other hand, states that, after having been in the gas-bath from fifteen to thirty minutes, he felt very warm and comfortable; and that symptoms similar to those described by Collard, only came on if it was prolonged beyond that period. The gas seems also to be carried to the intestines which, according to Welsch, become distended, and after the bath, ructus, flatus, and a more considerable discharge of faeces, generally takes place. After a carbonic acid gas-bath, there is in most cases copious perspiration on the inner surface of the thighs,

the loins, and the generative organs; especially if the gas has been heated to 80° or 90°. Such baths generally leave a feeling of increased vigour and comfort; but some persons feel chilled after their use.

The effects of bathing in water impregnated with carbonic acid, are somewhat different. These vary very much according to the temperature of the water. If the bath is cold, a sensation of burning in the skin, and an internal chill is felt, but if the temperature is 86° or 88°, no chill is perceived. As soon as the patient is immersed in water which contains much carbonic acid, the whole surface of the body becomes thickly covered with bubbles of carbonic acid gas, which are in constant motion; and if wiped off, they immediately reappear. In the skin a feeling of pricking and heat is produced which, on the scrotum, the back of the hand and of the forearm, on the face (when immersed), on the nipples, and the labia, amounts to a burning sensation. The more carbonic acid the water contains, the more pleasant is this "champagne-bath". If the patient remains quite motionless in it, the burning sensation is to a certain degree increased, as the gas-bubbles remain in closer contact with the skin; but if he moves about, a feeling of cold is perceived; and in many cases this continual change from cold to heat tends to strengthen the skin. During the bath the pulse becomes fuller, but not accelerated; the skin appears firm and red, its papillae swell, the scrotum is drawn upwards and considerably contracted, and many persons feel a burning sensation for several hours after-

wards. In males, even in such as are past the prime of life, the generative organs are powerfully stimulated. The baths have also a remarkable effect upon the bladder. The same patients who can sit in a common warm water-bath for half-an-hour, without feeling an inclination to pass the urine, are compelled to do so after having been immersed for only a few minutes in a carbonic acid bath. The inhalation of the gas which, of course, takes place in the bath, is by no means so unpleasant as might be supposed, the carbonic acid not being sufficiently concentrated to be able to extinguish a candle floating on the water; but if sensations of vertigo, oppression &c., are perceived, it is merely necessary to stand up in the bath now and then, and to breathe the pure air in the higher strata of the atmosphere, in order to obtain immediate relief.

The after-effect of a carbonated water-bath is, in most cases, a feeling of increased power in the limbs; and semi paralytic patients are observed to walk briskly afterwards. This effect is chiefly marked in females suffering from hysterical paralysis, and even in the commencement of atrophy of the cord, amelioration may be produced; while in cases of longer standing, in which the nervous matter is changed into "veritable starch", of course, no good can be expected.

Carbonated water when drunk, quenches thirst and has a pleasant effect upon the palate. In fact, carbonic acid is the chief spice contained in cold drinks, especially in fermented liquors. Water has a very flat taste when devoid of this gas, and even breast-milk is rend-

ered more palatable by it to the infant. Carbonated water stimulates the gustatory nerves, and the flow of saliva, and thereby promotes digestion; at the same time, the earthy salines which are contained in the food, are more easily dissolved. Aërated drinks are cooling, and are therefore ardently desired by patients suffering from acute diseases. This cooling is probably due to the absorption of oxygen and the combustion of tissue being retarded if much carbonic acid is present in the system; and also because, if it evaporates from the lungs, cold is produced. Animals, especially cattle, have great predilection for acidulous waters; this has been chiefly remarked in the neighbourhood of Vichy and Marienbad. A copious use of such waters, however, produces emaciation, probably on account of the salines which are at the same time ingested.

After drinking carbonated water, part of the gas is generally brought up by eructation; especially if the stomach is full, and the quantity of water drunk, considerable. Another part is absorbed and carried to the portal vein and the liver, and afterwards to the brain and other remote organs. Its effects on the brain are, therefore, in this case, not so immediate as if carbonic acid is inhaled by the lungs; nevertheless intoxication may result from it. If the gas is not quickly eliminated, but accumulates in the blood, it may produce asphyxia; this is sometimes caused by taking large quantities of white wine, in which fermentation is going on. "If", says Professor Liebig, "such wine is ingested, the fer-

"mentation is augmented by the heat of the stomach; "the carbonic acid evolved, penetrates through the walls "of the stomach and the diaphragm to the cells of the "lungs, and there displaces oxygen; death then ensues, "with symptoms of suffocation by an irrespirable gas. "A certain proof for the presence of too large a quan-"tity of carbonic acid in the lungs is, that in such cases "inhalation of ammonia is the best antidote."

If much carbonic acid is absorbed, the blood assumes a dark colour, which is probably due to an alteration in the shape of the globules of the blood. Harless has observed that the diameter of the blood-globules of the frog became enlarged, after they had been impregnated with carbonic acid. The blood-globules contain alkali bound to albuminous matter, and if they absorb an unusual amount of carbonic acid, this combines with the alkali; and it is possible that a more abundant amount of albuminous matter, or iron, may in consequence be carried to the intercellular liquid.

Acidulous waters taken in moderate quantities accelerate the pulse, render the head clear, and the mind cheerful. Large doses, as from ten to twenty tumblersful, cause sickness, vomiting, and congestion of the brain, which is shown by violent headache, vertigo, and tottering gait; and unless the carbonic acid is quickly eliminated, apoplexy may be the result. In such cases, the effects of carbonic acid are combined with those of a mechanical distension of the stomach, whereby a pressure upon the heart and the large blood-vessels is produced.

Amongst the remote effects of carbonic acid, those upon the contractile power of the muscles are chiefly remarkable. If dogs are brought into the Grotto of Pyrmont, the first symptom observed in them is tottering gait, followed by rigidity of the limbs, and paralysis. Again, if they are taken out and allowed to recover, the gait only becomes steady after all other symptoms of poisoning have disappeared.

Carbonic acid has the same effect upon the muscles, if applied to them locally. Humboldt has observed that, if a frog's leg was suspended in this gas, it lost its excitability much sooner than if suspended in dry air or oxygen. The same holds good for the involuntary muscles. The function of the heart may also be paralysed by it; but in this case there seems to be rather a temporary suspension, than a real weakening, of the heart's action, for if oxygen is again carried to the blood, the heart rapidly resumes its normal function. Regarding the iris, it is found that, after the inhalation of carbonic acid, the pupil is at first constricted; but if death ensues, it becomes dilated.

Carbonic acid is chiefly eliminated by the skin, the mucous membrane of the intestinal canal, and the lungs. Marcard relates the case of a lady who, after having inhaled the gas in the Grotto of Pyrmont for some time, discharged an enormous amount of flatus, and whose limbs had also become very much swollen. The kidneys seem only slightly instrumental in carrying off carbonic acid from the system. Mr Brande has stated that, after the use of acidulous waters, carbonic

acid is evolved from the urine, if this is heated and brought into the vacuum; but this assertion is contradicted by the experiments of Wöhler, Marcet, and others. Lehmann has, however, found that, after taking champagne or beer in which fermentation is going on, 0.53 and 0.68 volumes of carbonic acid were evolved from the urine. It appears that pain may be diminished by the application of carbonic acid to the suffering parts. Ingenhousz who is quoted by Lersch, experimented on a blister which he had produced on his finger. This became very painful, if the finger was put into oxygen, and less so, if it was surrounded by nitrogen or carbonic acid; the pain even disappeared entirely under such circumstances. The same observation has been made by Beddoes.

The mere stay in places where considerable quantities of this gas escape from the soil or from mineral springs, seems to exercise a peculiar effect upon certain persons, even if they do not drink the acidulous water, and keep at a distance from the inhalation-rooms. During the first few days, some feel a sort of pleasurable relaxation and sleepiness; while others again are indisposed and only recover, if they ascend to the heights in the neighbourhood of the Spa, where carbonic acid, on account of its specific gravity, cannot rise. In the neighbourhood of the inhalation-rooms of Franzensbad, and in other places where there are considerable escapes of this gas, trees will not grow. Landriani mentions that the Scirocco fatigues the Italians

chiefly on account of the large amount of carbonic acid, and the small quantity of oxygen, carried by it.

Carbonate of soda, which, together with carbonic acid, forms the chief ingredient of the alkaline acidulous springs, is a normal constituent of the blood, which it renders alkaline. It is also contained in the saliva, the bile, the mucus of the oesophagus and intestines, and the milk. The perspiration from the arm-pit, and from a few other parts of the surface of the body, is alkaline, while from most parts it is acid. If the alkalinity of the blood decreases, the solubility of the albuminous matter in the blood is also diminished.

The effects of carbonate of soda internally administered, are to exalt the natural alkalinity of the blood, and to render the urine alkaline. It also increases the quantity of secretions, and promotes menstruation. Its further effects in the system are still enveloped in much obscurity.—

I now proceed to describe the physiological effects of the alkaline acidulous springs, as far as they are at present known. The taste of the waters varies according to the quantity of carbonic acid and salines they contain, and is pleasant, if the former, and unpleasant, if the latter predominate in them. They stimulate the stomach and increase the appetite, but scarcely ever act as aperients, unless over-doses are taken, or a certain amount of sulphate of soda is also contained in the water. The perspiration of the skin is increased in a few cases only, while a diuretic action is the rule. The

mucous secretion of the bladder becomes less tenacious. Two or three glasses of Vichy water generally render the urine quickly alkaline, and a second such dose will cause it to continue so for twenty-four hours. In some persons, however, fifteen to twenty glasses are necessary for obtaining this result. According to the observations of d'Arcet, the urine becomes alkaline if thirty-three grains of the carbonate of soda are taken daily before breakfast, in the form of Vichy water; and the urine then continues alkaline for eight or nine hours. If forty-nine grains are taken, the alkalinity persists for almost twenty-four hours, and after sixty-six grains daily, the acid reaction of the urine disappears entirely. This action of the water differs, however, according to the state of the system generally, and also to that of the stomach. In such persons as suffer from an excessive amount of acidity of the stomach, the alkali is neutralised in the primae viae, and it therefore has no power to alter the reaction of the urine. If the stomach of a healthy person is empty, there is little gastric juice and acid present in it: and if the full action of the alkali is intended, the water should, for this reason, be taken before breakfast. On the other hand, large doses of such waters produce irritation and inflammation of the stomach and the kidneys, whereby the urine may also be prevented from becoming alkaline. This is the reason why in some cases the urine is rendered alkaline by small doses of the Vichy water, and remains acid if large quantities of it are taken.

Some patients, after having taken the alkaline acidu-

lous waters for a few days, complain of slight febrile symptoms, fulness in the head, weariness of the limbs, a feeling of intoxication, general lassitude &c.; but these symptoms soon disappear, and a feeling of increased vigour ensues. But after the Spas have been used for several weeks in succession, these symptoms are apt to return, and they then indicate the saturation of the system, when it is generally advisable to discontinue the use of the waters. If this is nevertheless continued, the composition of the liquids and tissues of the body may become seriously altered. Digestion becomes slow and imperfect, and any exertion of body or mind difficult. At the same time the pulse is retarded; and in a case observed by M. Civiale, in which there had been a too prolonged use of the Vichy water, the rate of pulsation was only fifty-six per minute. The slightest fault in the diet, or any other accident, may, under such circumstances, induce general prostration. M. James states, that such persons sometimes look as if affected by ague. The feet swell, the gums become soft, and are apt to bleed; but it is doubtful, whether the teeth fall out, or the bones are softened, as has been stated by a few observers. On the other hand, there are cases on record, in which the use of the waters has been continued for a very long time without any unpleasant consequences. Thus Thilenius has related the case of a man who suffered from gravel, and who drank a jug of Fachingen water every day for the space of ten years, with the result that during the last five or six years he was in perfect health.

Medicated baths.

Before entering into a discussion of the effects of alkaline acidulous baths, we must consider the question, whether or not, medicinal substances which are added to a bath, are absorbed by the skin and received in the blood. It was formerly believed that the skin was permeable to all such salines as were easily soluble in water; and that, if we wished to introduce such substances into the system, the addition of them to baths was nearly as efficient as their internal administration. Recent experiments have, however, gone far to dispel this belief. M. Kletzinsky has experimented with baths to which ferrocyanide of potassium, sulphate of magnesia, sulphate of iron, iodide of potassium, borax, acetate of lead, nitre, sulphuret of potassium, and other substances, had been added; but he never discovered a trace of any of them in the urine, even after a prolonged stay in the bath. M. Homolle was led to similar results, inasmuch as after an addition of iodide of potassium, he could not discover any iodine in the urine; nor was he able to find cyanurets in it after baths to which ferrocyanide of potassium had been added. If baths with carbonate of soda were taken, an increased quantity of this substance was found in the urine; but after a bath with tablesalt, there was no surplus of chlorides in the urine, which were, on the contrary, diminished. M. Durian, who has also investigated this subject, was unable to find carbonate of potash, alum, sulphate of quinine, infusion of digitalis and of bella-

donna, in the urine, after baths containing these substances had been taken; and Dr Braun could not discover a trace of iodine, after prolonged footbaths with iodine and iodide of potassium. The only observer who asserts, that chloride of sodium and bichloride of mercury are easily absorbed by the skin, is Dr Clemens, of Rudolstadt*; but as his statements are directly at variance with the uniform results obtained by a large number of excellent experimentalists, we shall require more convincing proofs for the accuracy of his observations than have hitherto been given, before we can set aside the conclusions previously arrived at by others.

Although it would therefore appear that there is no absorption of medicinal substances by the skin, if such are added to baths, it by no means follows that the effects of medicated baths are identical with those of ordinary water-baths. On the contrary, there can be no doubt that the former have a very powerful action on the skin, and may, by reflex from the surface of the body, exercise considerable influence upon remote organs. Medicated baths tend to render the urine alkaline. M. Durand Fardel found this to be the case during and after baths with Vichy water**, and Musset made the same observation with baths of Plombières water. Homolle noticed that, if chloride of sodium, iodide of potassium, and ferrocyanide of potassium were added

* Allgemeine medizinische Centralzeitung. No. 76. 1861.

** L'Union médicale 1853. 18—20.

to the bath, the urine became more strongly alkaline than after baths of alkaline water. According to M. Poulet, even baths with an addition of acids, cause the urine to become alkaline. After bathing in Ems water, Dr Spengler found, that the acidity of the urine was diminished. M. Durian says that the urine almost always became strongly alkaline, whatever might be the nature of the medicinal substance added to the bath. Dr Beneke, on the contrary, remarks, that sea-bathing augmented the acidity of the urine. Dr Neubauer mentions an increased acidity of the urine as an effect of bathing in the Wiesbaden thermal water, and Dr Lehmann states that the same is caused by the brine-baths of Rehme. Further investigations of this subject would be very desirable, as our knowledge in this particular is still very deficient. —

According to M. Durand-Fardel, baths of Vichy water render the urine neutral, and even alkaline, in less than an hour; and in the further course of the treatment, the perspiration and the saliva also become alkaline. We have already seen that ordinary warm water baths, and medicated baths of the most various kind, have the same effect upon the urine; and the action of the Vichy baths upon the perspiration and the saliva, is also no doubt due to the local influence of the water upon the skin; the absorption of bicarbonate of soda from the bath being highly improbable. The thermal water of Vichy is, when used for bathing, generally diluted with ordinary water, as the skin is much irritated by pure thermal water.

2. MURIATED ALKALINE ACIDULOUS SPRINGS.

Chloride of sodium which, together with carbonic acid and bicarbonate of soda, forms the chief constituent of the muriated alkaline acidulous springs, is a normal ingredient of the blood and of all the tissues of the human body. Lersch has calculated that, on the average, twenty grains of this substance are daily ingested with the food taken, independently of the tablesalt with which our dishes are seasoned. The amount of tablesalt daily taken as spice, considerably varies in the different countries, and in individuals according to taste. The white inhabitants of the Patagonian Pampas, and the blacks of Mauritius, do not eat any tablesalt, while Europeans use from two to eight drachms, and Russians two ounces and more, per diem.

The quantity of chloride of sodium in the blood is invariable under ordinary circumstances, and amounts to seven parts in one thousand parts, that is, about thirty-three grains in the pound of blood, and forty-four grains in the pound of serum. In the bones of the human body, from 150 to 500, and in the muscles, from 300 to 600 grains, of chloride of sodium are found. The brain contains only little of this substance; in the lungs, according to Dr Beale, eleven grains are contained in the pound; and the whole amount of this substance in the human body, may be calculated at from one thousand to two thousand grains. By far the largest portion of chloride of sodium is eliminated by the kidneys, only little being carried off by the bowels·

The quantity of chloride of sodium daily excreted by the urine, differs according to the amount of it which is ingested; and varies in adult males from 64 to 112 grains, in women from 11 to 16 grains, in old persons from 8 to 24, and in children from 32 to 80 grains. The urine contains the largest proportion of tablesalt some time after meals, the maximum being found from three to six hours after dinner. Chloride of sodium disappears from the urine if the food is not seasoned with tablesalt, and also in patients suffering from pneumonia, where it is probably used up for the exudation matter. In persons whose skin acts freely, and who are in the habit of taking a considerable quantity of tablesalt, part of it is excreted by the skin. If unusually large quantities of tablesalt are ingested, all secretions, such as milk, tears, saliva, bile &c., become rich in chloride of sodium; but it has not yet been ascertained whether the tissues also contain more of this substance under such circumstances. The blood seems to become richer in chloride of sodium only after large quantities of it have been taken for a considerable time. M. Plouviez took 164 grains of it daily for three months, and found after this period that 10,0 0 parts of his blood contained 123 parts less of water, 30 parts less of albumen, 130 more of globules, 15 more of fibrine, a little more fat, and 25 more of chloride of sodium than before. This subject, however, requires further elucidation.

The want of tablesalt in the system entails very serious consequences. D^r Wundt, after having for three

days taken food unseasoned with tablesalt, found that the urine contained albumen, and had become neutral, and even alkaline; but after he had recommenced using tablesalt, the urine had in two days, returned to its normal condition. Mungo Park relates that, if he was without tablesalt in his travels in the interior of Africa, he felt very weak, and digestion became greatly disturbed; and that the want of tablesalt was much more painful to him than thirst.

Tablesalt is a very important element in the process of cell-formation. All exudation matter contains a large proportion of this substance, which also seems to be of particular importance for the growth of hair. M. Rigaux has remarked that the naked fur of rabbits became thicker and covered with hair, after the animals had for some time been fed with salt: and it is well known to farmers that sheep yield better wool if some of this substance is added to their food. In places where the soil is rich in chloride of sodium, the growth of hair in the inhabitants is very abundant, and it even appears on the surface of wounds.

The chief symptoms observed after taking chloride of sodium, are: a pappy taste, scratching in the throat, fulness in the epigastrium, increased appetite, ructus, flatus, and excitation of the peristaltic motion of the bowels. The faeces are rendered more fluid and are more easily voided, there being a more abundant secretion of the intestinal mucus, and desquamation of epithelial cells. Chloride of sodium, however, does not

withdraw so much water from the blood as sulphate of soda, and is therefore not a strong aperient.

Chloride of sodium essentially promotes digestion. It not only causes a more considerable secretion of gastric juice and bile, but it also facilitates the absorption of chyle by the capillary vessels of the intestines; and it is effectual in preventing fermentation and putrefaction in the intestinal canal. Moreover, as the phosphate of lime is more easily soluble in a solution of chloride of sodium than in ordinary water, the absorption of this important substance is facilitated. Tablesalt also kills intestinal worms, especially ascarides, which latter are very common in persons who, through prejudice or necessity, abstain from the use of it. Amongst the remote effects of this substance, I may mention that the generative organs are excited, and according to Dr de Sauve, the fecundity of both sexes is increased by its use. With regard to its effect upon the composition of the urine, it seems certain that the formation and elimination of urea is augmented. M. Barral has found that, after additional quantities of tablesalt had been taken, the amount of urea excreted rose from 2.84 to 6.02, and even 9.42 grammes per diem; and Bischoff noticed, that in dogs the weight of the body was at the same time much diminished. It would therefore appear that tablesalt promotes the retrogressive metamorphosis of matter.

If large quantities of chloride of sodium are taken, the stomach and the intestines, and even remote organs, may become subject to inflammatory irritation.

The flow of urine is increased, and a sensation of burning caused along the course of the uretheres; the secretion of the conjunctiva ând the Schneiderian membrane is either augmented or entirely stopped; bronchial catarrh may set in, and itching is frequently felt, especially in the skin of the lower extremities. If the quantity of salt absorbed is very large, the brain also becomes affected, and death ensues after great sufferings.

The physiological action of the muriated alkaline acidulous springs is due to the water and its temperature, and to the carbonic acid, bicarbonate of soda, and chloride of sodium contained in them. By the internal use of Ems water, which is the most important Spa of this class, the urine is generally rendered alkaline after a certain time; in some cases it remains clear, while in others it becomes turbid. The acidity of the urine is likewise diminished by bathing in Ems water; but this is no reason for assuming an absorption of alkali by the skin. The internal use of the water is sometimes followed by considerable diuresis and diaphoresis, while at other times purging is induced. If the weather is damp, diuresis is increased; but in dry weather, and in persons whose skin acts freely, the water has a more diaphoretic effect. Its action also depends in some measure upon its temperature, and upon the quantity of water taken. If, for instance, a considerable amount of the Krähnchen water, which has a temperature of 71°, is ingested, purging may be the consequence; but after a moderate internal use of the

Kesselbrunnen, which is at 115°, constipation is more apt to follow than diarrhoea. By the carbonic acid and the high temperature of the spring, the nervous system frequently becomes excited, and vertigo and sleeplessness ensue.

Dr Spengler has discovered that Ems water excites the motion of the ciliated cells and of the spermatozoa. From this he has drawn the conclusion that the beneficial action of Ems in pulmonary catarrh may be due to the influence of the water upon the epithelium of the air-passages; and that the effects of the same Spa in curing sterility, may be ascribed, partly to a diminution of the acidity of the vaginal and uterine mucus, which according to Donné is very detrimental to the viability of the spermatozoa, and partly to the direct action of the water upon the spermatozoa themselves.

The physiological effects of the other muriated alkaline acidulous springs are even less known than those of Ems; and it is greatly to be desired that experiments on this important subject should be undertaken, especially with the waters of Selters and Salzbrunn, and with those of Luhatschowitz, which latter contain not only carbonic acid, bicarbonate of soda and chloride of sodium, but also a not inconsiderable quantity of iodine and bromine.

3. ALKALINE SALINE SPRINGS.

The chief contents of these springs are bicarbonate and sulphate of soda. Only very little of the latter

substance is contained in the blood and the tissues of the human body, and the average quantity of sulphates daily discharged with the urine amounts to thirty grains.

If small doses of the sulphate of soda are taken internally, the saline is absorbed and excreted by the kidneys, and in women during lactation, also by the mammae. Large quantities of it, such as two drachms or half an ounce, produce diarrhoea; at the same time the pulse is accelerated, and according to Heller, the elimination of uric acid through the kidneys is augmented. The effects of such doses are only temporary; but if by the simultaneous administration of opium, the saline is allowed to remain in the bowels for a somewhat longer period, catarrh of the intestines is produced. Sulphate of soda abstracts a much larger amount of water from the blood than chloride of sodium, the endosmotic equivalent of the former being, according to Professor Jolly, nearly treble that of the latter. Sulphate of soda, when introduced into the intestines, is said to cause a secretion of water equivalent to twelve times the quantity of the saline ingested. If half an ounce or an ounce of this substance is taken, purging begins three to four hours afterwards, and generally lasts for eight or nine hours. The greatest portion of the saline is then eliminated with the faeces, and only little by the kidneys.

Baron Liebig has endeavoured to explain the purgative action of the sulphate of soda in the following manner:—if it is given in a solution containing a larger

amount of solid matter than is to be found in the serum, the equilibrium between the two fluids must, according to the laws of exosmosis, be restored; and this is effected by water from the blood rushing into the intestinal canal, in order to dilute the more concentrated liquid, which is separated from it by a permeable membrane. It has, however, been shown by the experiments of Wagner, Buchheim, and Aubert, that the purgative effects of the sulphate of soda are not dependent upon the more or less concentrated solution administered, but that it acts as an aperient, whether it be taken in the form of dried crystals, or dissolved in a large quantity of water; and that if much water is given at the same time, the purging, on the contrary, becomes even more considerable than otherwise. In the bowel, part of the sulphate is changed into sulphuret of sodium; and the faeces appear dark-green, especially if the water taken also contains iron; in which case sulphuret of iron is formed. This occurs, for instance, if Marienbad water is drunk. The continued use of sulphate of soda disturbs digestion and lowers animal temperature.

The most important alkaline saline waters are the cold springs of Marienbad and Tarasp, and the thermals of Carlsbad. The following are the physiological effects of Marienbad water, which holds in solution nearly double the quantity of sulphate of soda contained in the Sprudel of Carlsbad:—

If a healthy person takes six ounces of Kreuzbrunnen, every quarter of an hour, before breakfast, the

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effects of the carbonic acid gas, of which from nine to twenty-two cubic inches are contained in the pound of water, are the first to be perceived. These are a sensation of heat in the stomach, and in sensitive persons headache and sleepiness. If after the dose mentioned, diarrhoea follows, this is probably more due to the low temperature of the water and the walking exercise taken at the time of drinking, than to the physiological action of the sulphate of soda. Four or six tumblersful of Kreuzbrunnen, however, always excite the action of the bowels; the faeces are fluidified, and assume a darker colour, owing to the sulphuret of iron formed in the intestines. At the same time the appetite is increased; the urine becomes more abundant and diluted; and if large quantities of the water are taken, the urine may even be rendered alkaline. In many cases perspiration is augmented. The secretion of the mucous membranes generally is increased, and sometimes eruptions of the skin, acceleration of the pulse, and haemorrhoidal bleeding follow. Although the elimination of matter from the system is considerably accelerated, the effects of the water are not so weakening as those of the pharmaceutical preparations of the sulphate of soda; since the carbonic acid and the carbonate of protoxide of iron contained in the water, promote digestion and prevent the blood from being too much impoverished.

Although the springs of Carlsbad have been extensively used for the cure of disease for more than five centuries, our knowledge of the physiological effects

of these waters was until recently, exceedingly deficient. "The most fantastic theories" (says Dr Seegen, of Carlsbad, in a letter to the author) "have for a long "time existed concerning the physiological action of "these springs, and which were in no way based on "experience. The grand and imposing manner, in which "the Sprudel rises from the earth; the incrustating power "of the water, and finally, its striking curative properties, affected the imagination of Physicians and laymen in an equally powerful manner, and the water "was endowed by them with the most wondrous qualities. Some maintained that it was very exciting. The "most fiery wines were as nothing when compared to "this volcanic water; with one tumblerful of Sprudel a "stream of subterranean fire was introduced into the "system and rolled through the veins, where it might "cause the most destructive effects, the least dangerous "of which was apoplexy. Others compared the water "with iodine and mercury, and asserted that the absorption was so quickened by it, that, by an incautious use of it, the whole system might be absorbed, "and eventually disappear altogether; especially if while "using it—a fault in the diet was committed. I have heard "it related by two faithful *habitués* that a man, after "having taken a glass of Sprudel and eaten two cherries upon it, died immediately afterwards. The "post-mortem examination showed two stones in the "stomach; and it was, therefore, evident that the water "had petrified hte cherries.

"A sober observation does not perceive any of these

"marvellous effects. It is certain that Carlsbad water "accelerates circulation in some measure, as every warm "beverage will do, merely by its high temperature. "This is, of course, more striking if the hot springs are "used. The function of the skin is also excited, and "perspiration increased. The effect upon the kidneys "is only trifling. The function of the intestines is moder-"ately excited, and a really laxative effect is very rare; "if this latter occurs, it is generally due to over-sensi-"tiveness of the bowels, or to the use of very large "quantities of the water. The secretion of the bile is "increased, and the composition of this liquid is proba-"bly altered. The high temperature facilitates the ab-"sorption of the water, and at the same time prevents "loss of animal heat."

The taste of Carlsbad water is slightly saline and alkaline, and resembles that of weak mutton-broth. If it has been standing for some time, the taste becomes more strongly alkaline, and consequently more unpleasant. As only very little ordinary spring-water is to be had at Carlsbad, not only patients, but also the inhabitants, and the cattle, are in the habit of taking more or less considerable quantities of Sprudel. If a moderate amount of it is drunk, no striking effects of any kind are produced in healthy persons. The water seldom causes sickness. In former times, when it was customary for patients to drink from three to ten quarts of Sprudel per diem, and even more, and when it was not taken in the immediate neighbourhood of the spring, but carried into the house of the patient,

where it was only drunk after having become cold and lost its carbonic acid, purgative effects were more frequently observed than they are nowadays; and Carlsbad has, for this reason, unjustly acquired the reputation of being a strongly aperient water. In many persons no purgative effects whatever are produced by the Carlsbad water; and even the addition to it of Carlsbad salt, is not always sufficient for relieving the constipation which not unfrequently follows. Kreysig has observed a number of cases in which the water only caused more abundant evacuations after it had been taken for a lengthened period; and that there was diarrhoea for a day or two, after which the appetite was considerably increased, and the digestion promoted. In most cases defaecation is moderately increased, while in some there is obstinate costiveness which cannot be removed by prescribing larger quantities of the water; in such cases it is necessary to clear the bowels by enemata or purgatives; and the normal action of the intestines then only gradually reappears after several weeks have elapsed. In some persons, Carlsbad water causes salivation, even when mercury has not been previously given. The quantity of the biliary constituents of the faeces is generally augmented. The faeces frequently appear black in the second week of the treatment; they afterwards become green, and then brown; and towards the end of the course, their colour is again dark-green. Sexual desire is sometimes increased; but diuretic effects are scarcely ever observed, and if such are desired, the Physicians of Carlsbad pre-

scribe other mineral waters which are known to produce these effects with certainty. The urine is generally alkaline in the morning, a short time after the water has been drunk; but that discharged in the evening and during the night, is always acid, even if the use of the water has been long continued; unless the acidulous alkaline water of the neighbouring Spa Giesshübel, which is often prescribed to be taken in the afternoon, and which contains a considerable quantity of bicarbonate of soda, is drunk at the same time. If Carlsbad water alone is taken, the urine is hardly ever found to be alkaline after one o'clock p. m.; and in many patients it regains its acidity by 11 o'clock a. m. If very large quantities of Carlsbad Sprudel are taken, unpleasant symptoms quickly follow, such as general excitement, sleeplessness, headache, vertigo, epistaxis, dimness of vision, ringing in the ears, palpitations of the heart, pain in the region of the liver and the spleen; and even apoplexy has sometimes been the result. In excitable persons, therefore, the Neubrunnen and Marktbrunnen, which have a lower temperature than the Sprudel, are generally preferable to the latter. The following results are also mentioned by different writers to have followed the use of the water:—softening of callus, haemorrhoidal bleeding, breaking up of wounds which had already been closed, fresh paroxysms of suppressed ague, and extensive desquamation of the epiderm s.

Dr Seegen, of Carlsbad, has recently undertaken a series of exact physiological experiments with this wa-

ter, which have led to important results. He experimented upon nine persons whose condition was examined from six to seven days before, and from seven to nine days during, the administration of the mineral water; special regard being had to the faeces, the quantity, specific gravity and reaction of the urine, the quantity of urea, uric acid, phosphoric acid, chloride of sodium, sulphuric acid, and the weight of the body*.

1. The quantity of faeces voided was considerably increased in two persons only. It remained unaltered in three, while in two others costiveness ensued, which did not yield to the administration of large quantities of the mineral water.

2. The quantity of urinary water was diminished in one case out of seven; in another it remained unaltered; and in five, it was increased. In each of these cases, however, the increase was not equal to the increased quantity of water taken. Thus one person drunk, during the experiments, 1500 cubic centimètres more water than he had done before; and the increase of urinary water in this case, amounted to 800 cubic centimètres only. (This experiment was made in winter, and it is, therefore, not probable, that the excess of water should have been eliminated by the skin. Nevertheless, it would have been better if the quantity of water eliminated by the skin and the lungs, had also been determined.) In another person, the urinary water increased by 600

* Physiologisch-chemische Untersuchungen etc. Wiener Medizinische Wochenschrift. 1860. No. 22, 46, 48, 50, 51.

cubic centimètres, after the administration of 1200 cubic centimètres of mineral water; in a third, the quantity of urine passed fell from 2075 to 2059, although 1045 cubic centimètres of mineral water were taken. *Carlsbad water is, therefore, neither a purgative nor a diuretic.*

3. The specific gravity of the urine was in some persons more or less diminished, while in others it was increased. It was always inversely proportional to the quantity of urinary water discharged, there being an increase of the specific gravity if diuresis was diminished; and a decrease, if it was augmented. Thus, in one case, in which the quantity of urinary water rose by 600 cubic centimètres, the specific gravity fell from 1023.66 to 1013.33. On the whole it appeared, that the amount of solid constituents of the urine was not perceptibly altered by the use of the mineral water.

4. The reaction of the urine remained acid in three persons. In another, the urine was neutral in the morning, after the water had been drunk, and regained its acidity in the afternoon. In three cases the urine was, for the last few days of the experiments, rendered alkaline in the morning. That passed during the night was always acid.

5. The quantity of urea was diminished in four persons, although three of them took, during the time of the experiments, more nitrogenous food than they had done before; so that an increased elimination of urea might rather have been expected. In two other persons, the quantity of urea remained unaltered, and

in one only an increase of 107 grains took place. This latter person, however, had taken a much larger quantity of meat during, than before, the experiments. The diminution of urea which was thus shown to be the average result, is so much the more striking, as the persons experimented upon took from 1200 to 1500 cubic centimètres more water than they had done before; and experience has shown that, by drinking an additional amount of water, the elimination of urea is generally augmented.

Urea being the product of combustion of nitrogenous matter, its diminution appears equivalent to a limited waste of such tissues. It should however not be overlooked, that azote is not exclusively eliminated by the kidneys, but also by the skin, the lungs, and the intestines. M. Barral asserts that the quantity of azote removed through these latter canals, is nearly one half of the entire quantity of azote eliminated from the system*. It would, therefore, be necessary to determine the amount of nitrogen lost through all organs of secretion and excretion, before we could affirm with any degree of certainty, that the waste of nitrogenous tissues was really diminished by the use of Carlsbad water. On the other hand, the researches of Bischoff and Voit** on dogs go far to prove that nearly the whole amount of nitrogen is excreted by the kidneys; which is confirmed by the results of the investigations

* Statique chimique des animaux etc. Paris 1850.

** Die Gesetze der Ernährung des Fleischfressers. München 1860.

of Bidder and Schmidt, who made their experiments on cats. We shall presently see that the elimination of sulphates and earthy phosphates, which are also products of the combustion of nitrogenous tissues, are equally diminished by the use of Carlsbad water; from which it would certainly appear, that this Spa is able to retard the waste of azotic matter in the system.

Bischoff and Voit have shown that, if meat and fat are given to dogs, less urea is excreted than if lean meat alone is given them. It is possible that this is caused by the fat absorbing the oxygen present in the body, so that azotic matter cannot be so extensively destroyed as would otherwise be the case. The limited waste of nitrogenous tissue, which would seem to be caused by the use of Carlsbad water, may also be due to an increased combustion of fat. At all events, the therapeutical experience made at that Spa shows that, by the use of this mineral water, adiposity is cured, and that fatty degeneration of the liver is, amongst all diseases of that organ, the one most likely to be benefitted there. The favourable results obtained by the use of Carlsbad water in certain cases of diabetes, may also be due to its promoting the oxidation of carbon and hydrogen.

6. The quantity of uric acid was more or less diminished in all cases in which it was searched for. Within the first few days of the experiments, some of the persons who drunk the water, still discharged a not inconsiderable amount of uric acid; but it gradually diminished, and at last disappeared altogether. Dr

Seegen is inclined to think this due to uric acid being changed into urea; although it is difficult to say what becomes of the excessive amount of urea which would thus be formed, inasmuch as we have seen before that the elimination of urea is diminished by the use of Carlsbad water. We know that diseases depending upon an excessive formation of uric acid in the blood, as gout and lithiasis, are improved and cured by the use of Carlsbad water; but whether these curative results are due to oxidation of uric acid, it is at present impossible to determine. It seems more probable that uric acid combines with the soda contained in the Carlsbad water, and is eliminated as urate of soda which is easily soluble.

It is generally believed that, as the urine becomes neutral or alkaline during the use of Carlsbad water, uric acid must disappear from the urine; but mere alkalinity of the urine does not exclude the presence in it of large quantities of uric acid.

Uric acid diathesis is not always the cause of the formation of gravel and renal calculi. Many patients suffering from this complaint have been cured by Vichy and Carlsbad water, although the concrements did not consist of uric acid, but of earthy phosphates. It cannot therefore be supposed that these waters act by merely dissolving the concretions which may have been formed. It is much more probable that the formation of concrements of various chemical composition, is caused by catarrh of the calices of the kidney; and

that, if this is cured by the use of the water, the cause of the disease is removed.

7. The elimination of phosphoric acid was increased in six cases. This increase which varied from twenty to fifty per cent, merely concerned the phosphoric acid bound to alkalies; while the earthy phosphates were diminished in three cases out of four, in which a separate analysis of the alkaline and earthy phosphates was made. According to C. Schmidt, the alkaline phosphates form the largest portion of the inorganic substances contained in the blood-globules; and M. Nasse has found, that the amount of alkaline phosphates found in the ashes of the blood, is quite proportionate to the number of blood-globules. An increased elimination of alkaline phosphates would, therefore, seem to be equivalent to an increased waste of blood-globules. I will here add that Dr Hlowacék, of Carlsbad, has found that, if blood was let at the commencement of the use of the mineral water, it frequently had a dark colour, but that it became lighter and thinner in the course of, and after, the treatment.

8. Chloride of sodium was in three persons increased by 40.5 grains, while in four others the amount fell by 103.2 grains. As 1200 cubic centimètres of Carlsbad water contain 15.3 grains of chloride of sodium, so that in all persons experimented upon an additional quantity of this substance was ingested, the amount of chloride of sodium discharged by the urine would appear to be decidedly diminished in consequence of the use of the mineral water.

9. Sulphuric acid was only searched for in two cases, and in these it was found increased (by 2.85 and 12 grains). As an additional amount of 21 grains of sulphates was ingested with the water, the elimination of sulphuric acid seems to be diminished by the use of Carlsbad water.

10. The weight of the body was increased in all persons during the time they drank the water. This increase averaged sixteen ounces. In one person it was forty-eight ounces, but this was no doubt due to a retention of faeces, the bowels having in that case only once been voided during the space of nine days. In one person, the increased weight amounted to three pounds three ounces and a half.

The results of these investigations will no doubt serve to dispel the notion which formerly prevailed, that Carlsbad water was a formidable remedial agent, and only suitable for vigorous constitutions. Experience has, moreover, shown that this water may be administered to delicate children, pregnant women and old persons, without fear of any evil effects following, provided it is judiciously used. —

Dr Hlawacék has investigated the action of the Carlsbad mineral water baths. He took baths with Sprudel water for twelve consecutive days, and found that the urine and the perspiration soon became alkaline. Two days after the twelfth bath diarrhoea ensued. The baths moreover produced considerable congestion of the head, but the pulse fell by ten beats.

4. BITTER-WATERS.

The chief contents of bitter-waters are the sulphates of soda and magnesia. The action of the sulphate of magnesia is almost exactly similar to that of the sulphate of soda; but it seems that the former is more noxious to the system than the latter. Lersch states that after an injection of the sulphate of magnesia into the veins, the heart and the voluntary muscles become paralysed, while after an injection of the sulphate of soda, the contractile power of the muscles is in no way diminished.

The most important bitter-waters are those of Püllna, Sedlitz, and Saidschütz, and those of Kissingen and Friedrichshall. The two latter are distinguished by containing, besides the sulphate just mentioned, a considerable amount of chloride of sodium, by which their action is so advantageously modified that they should be used with preference whenever the use of bitter-waters is required. A protracted use of such bitter-waters as contain only sulphates, greatly disturbs digestion; they cause a considerable accumulation of fluid in the intestinal canal, and only very small quantities of them are absorbed. A proportionate mixture of the chloride of sodium and the sulphates of soda and magnesia, seems to prevent any injurious effects following. The bitter-water of Kissingen merely differs from that of Friedrichshall by containing a certain amount of carbonic acid, whereby it is rendered more palatable and easier of digestion.

The physiological effects of the Friedrichshall bitter-water have been minutely investigated by Dr Mosler, of Giessen, who made his experiments, for a period of thirty-six days, on three persons, viz. on himself, on a student of 21, and a woman of 39 years of age; special regard being had to the weight of the body, animal temperature, the rate of pulsation and respiration, the faeces, the quantity, specific gravity, reaction and colour of the urine, and the quantity of urea, chloride of sodium, sulphates and uric acid, during and after the use of this mineral water. The three persons mentioned took, during the whole time the experiments were continued, the same amount of solid and liquid food. In order to determine the normal condition of the body and its secretions, no bitter-water was taken during the first period of nine days; in the second and third period, of nine days each, doses varying from 2250 to 3750 and 7680 grains, of the mineral water were drunk, before and after breakfast; in the fourth period, the bitter-water was discontinued, and its after-effects were observed. These researches have led to the following results.

1. The faeces were only slightly increased if 2250 grains of the mineral water were drunk; 3750 grains of the same caused an increase of 1545 grains of faecal matters; and if the same quantity of bitter-water was drunk before breakfast, the surplus of faeces discharged was even 2010. Sixteen ounces of the water taken after breakfast, caused an increase of 1155 grains of faecal matters in one person, and of 6750 grains in an-

other. After thirty-two ounces taken before breakfast, the increase was 17,250 grains, and after breakfast, 12,240 grains. From this it appears that the purgative action of the mineral water is more considerable if taken on an empty stomach. The faeces voided have a darker colour, which is probably owing to an increased quantity of biliphaeïne.

2. The quantity of urinary water was also increased by the use of this water. If 2250 grains were taken before breakfast, the increase of urinary water amounted to 690 grains; 3750 grains taken after breakfast caused an increase of 8175 grains; and the same quantity taken before breakfast, one of 7380. The increase was 8760 grains, if sixteen ounces were drunk after breakfast; and only 1320 grains, if the same quantity was taken before breakfast. Thirty-two ounces drunk before breakfast caused an increase of 8250 grains; and after breakfast, one of 13,695 grains. The water, therefore, acts more upon the bowels and less upon the kidneys, if drunk before breakfast; while opposite effects take place, if it is drunk after breakfast. The secretion of urine remained increased for several days after the use of the mineral water had been discontinued; it was 7995 grains in one person who had taken 3750 grains, and 4275 grains in another who had drunk thirty-two ounces of the mineral water. The diuretic effects seem therefore more developed if small quantities of the water are administered; but they are always considerable, for, even if the water was drunk before breakfast, when the surplus ingested was carried off by the

bowels, the quantity of urinary water was nevertheless much increased. The water should therefore, if prescribed for patients, be drunk by them before breakfast if we wish to cause a purgative action, as in certain cases of engorgement of the liver, gall-stones, congestion of the lungs and the brain, haemorrhoids &c.; and it should be taken after breakfast, if we desire to act on the kidneys, as in dropsy, pleuritic exudations &c.

3. The specific gravity of the urine fell from 1026 to 1021.4 in one of the three persons, while taking 3750 grains of bitter-water. In another person it remained stationary at 1025, during the use of 2250 grains; but rose to 1026, if 3750 grains; and to 1027, if sixteen ounces were drunk. In the third person the specific gravity of the urine remained altogether unaltered; although the quantity of urine passed was greatly augmented. It therefore appears that, on the average, the elimination of the solid constituents of the urine is increased after taking certain quantities of bitter-water.

4. The reaction of the urine continued acid in two persons; in one, who took thirty-two ounces of the mineral water, the urine, after standing for some time, became alkaline sooner than it had done before.

5. The quantity of urea rose from 607.6 to 613.8 grains, if 2250 grains of the water were drunk before breakfast. In another person, it rose from 686.4 to 731.4 grains, after drinking 3750 grains of bitter-water after breakfast. The same quantity taken before breakfast, caused the urea to rise to 700.6 grains only, the bowels having acted more freely in this instance. After

the use of sixteen ounces before breakfast, which caused a large quantity of faeces to be discharged, the urea fell from 607.9 to 600.7 grains. After the use of the mineral water was discontinued, the elimination of urinary water and urea again rose, the latter amounting to 689.7 grains. Unless therefore a considerable evacuation of faeces takes place, the amount of urea excreted, is augmented by the administration of the bitter-water. If, on the contrary, the bowels are very active, some portion of the urea formed may be eliminated with the faeces, and there is no increase of it in the urine; but as soon as the diarrhoea ceases, an increased quantity of urea is again eliminated by the kidneys.

6. The quantity of uric acid, before the use of the mineral water, was 5.26 grains in one of the persons experimented upon. When 3750 grains of the water were drunk after breakfast, uric acid fell to 4.23 grains; and to 4.08, if the water was taken before breakfast.

7. The amount of chloride of sodium found in the urine, always corresponded to that of urea. The increase of tablesalt in the urine, which was observed after the use of the mineral water, was not entirely due to the additional quantity of it which was ingested with the mineral water; for after 2250 grains of the bitter-water, which contain 16.8 grains of chloride of sodium, had been taken, the latter rose in the urine from 194 to 216.15 grains; and after 3750 grains of the mineral water, in which 30 grains of chloride of sodium are contained, had been drunk, the latter rose from 185 to

238 grains, if the water was taken after breakfast; and to 251 grains, if it was drunk before breakfast. If sixteen ounces of the bitter-water were taken, by which quantity the bowels were considerably affected, the chloride of sodium rose from 194 to 240 grains. In this latter case, part of the chloride of sodium was no doubt eliminated by the bowels; for sixteen ounces of the mineral water contain 58.5 grains of chloride of sodium, and its increase in the urine merely amounted to 45.6.

8. The increase of sulphuric acid in the urine, which was also noticed during the experiments, was altogether due to the quantity of sulphates ingested with the mineral water. 2250 grains of this latter contain 27 grains of sulphates; and the increase of sulphates in the urine, after that dose had been taken, was only 13.9 grains. If 3750 grains of the mineral water, which contain 45 grains of sulphates, were drunk, these latter merely rose from 55 to 74 grains; and after sixteen ounces of bitter-water, containing 90 grains of sulphates, had been taken, the latter were only increased by 33 grains.

9. The rate of pulsation was not materially altered, if 2250 grains of the mineral water were taken; but after 3750, the pulse rose five beats; after sixteen ounces, five beats and a half, and after two pounds, five beats.

10. The rate of respiration remained unaltered after the use of 2250 and 3750 grains of the bitter-water; when sixteen ounces were taken, it rose from $21^3/_9$ to $22^8/_9$ in the minute; and when two pounds were drunk, it even rose to $33^1/_9$.

11. Animal temperature which was 99°.24 before

the experiments, rose to 99°.44 after 2250 grains of the mineral water; to 99°.71, after 3750 grains; and fell to 99°.32 after sixteen ounces had been taken.

12. The weight of the body decreased by 195 grains, if 2250 grains of bitter-water were taken for four days consecutively. After 3750 grains, the decrease amounted to 6960 grains; after sixteen ounces, to 12,255 grains; and after two pounds taken for nine consecutive days, to 24,075 grains. The body-weight again increased when the mineral water was discontinued; and had, after nine days, risen by 39,915 grains; the diet having remained unaltered during the whole time. The general health of the person who for nine days took two pounds of the bitter-water per diem, was very satisfactory. The waste of tissue induced by the use of the bitter-water was chiefly confined to the fat.

A considerable contrast has thus, by the researches of Drs Seegen and Mosler, been shown to exist between the Carlsbad and the Friedrichshall mineral waters. Friedrichshall water is both a purgative and diuretic; while Carlsbad water has only a very slow effect in stimulating the action of the bowel and may even cause constipation; and on the other hand, far from being a diuretic, it does not even allow the whole quantity of water ingested to be again eliminated. Friedrichshall water increases the elimination of the solid constituents of the urine and more especially that of urea and chloride of sodium; Carlsbad water, on the contrary, diminishes the excretion of urea, uric acid and chloride of sodium. Friedrichshall water if taken in large doses,

reduces the weight of the body, which is, on the contrary, increased during the use of Carlsbad water.

5. SIMPLE MURIATED WATERS.

The Spas of this class are distinguished by containing a somewhat considerable amount of chloride of sodium as chief ingredient. They increase the appetite, excite the mucous membrane of the stomach, promote the secretion of gastric juice and intestinal mucus, and accelerate the desquamation of epithelial cells; the faeces are fluidified, and their evacuation is thereby facilitated. The mucous membrane of the respiratory organs is likewise stimulated, and the general metamorphosis of matter considerably altered. After the use of the waters, the urine contains more urea than under ordinary circumstances.

Baths of muriated waters have also a considerable influence upon the system, and which is proportionate to the amount of chloride of sodium contained in the water. Chloride of sodium is not absorbed by the skin, but it acts as a powerful stimulus to the cutaneous nerves; it promotes peripheral circulation, and may, by reflex action, exercise a considerable influence upon remote organs, and even upon the centres of the nervous system. The elimination of matter through the skin and the kidneys is at the same time increased, especially if motherlye is added to the baths. Brine vapour-baths stimulate the mucous membrane of the respiratory organs, and promote expectoration.

The physiological effects of the muriated springs are considerably modified by the temperature of the water, which is very different in the several Spas of this class. The most important cold muriated waters are those of Kissingen and Homburg, which contain, besides the chloride of sodium, a very large amount of carbonic acid, by which, if the waters are used internally, the stimulation of the mucous membranes induced by the chloride of sodium, is further augmented; and if baths are taken, the combined effects of muriated and carbonated water upon the skin are produced. Two of the Kissingen springs also contain a small amount of carbonate of protoxide of iron, which was formerly believed to be an important constituent of the same; but it is more probable that it is only the water, the carbonic acid and the chloride of sodium, which are the really active elements of these springs. The mineral waters of Homburg contain a much more considerable amount of iron than those ofKissingen; and if the waters are used internally, this ingredient exercises great influence upon the composition of the blood. The taste of these waters is refreshing, slightly bitter, salty, and astringent. The secretion of saliva is generally diminished by drinking them; but they cause a tough and alkaline mucus to be secreted in the mouth and gullet. Eructations generally follow, and a feeling of warmth is produced in the stomach. Hunger and thirst are increased; the pulse becomes faster, fuller and harder, and diuresis is augmented. During the use of Homburg water, the faeces assume a dark colour, sulphuret of

iron being formed in the bowel. Concerning the effect of the waters upon the intestines, they at first not unfrequently produce costiveness, which is more especially the case with the Homburg water. The effect of the Kissingen waters upon the bowels is more considerable if it is allowed to stand for some time, as great part of the carbonic acid then escapes. The physiological effects increase in proportion to the quantity of water taken, and to the time their use is continued.

Amongst the muriated thermals, the Spas of Wiesbaden, Bourbonne-les-Bains, and Baden-Baden, rank first in importance. The two former closely resemble each other in their chemical composition, while the amount of chloride of sodium contained in the springs of Baden-Baden is much less considerable. The water of the Kochbrunnen, of Wiesbaden, tastes like chicken broth highly salted; it increases the flow of saliva and buccal mucus, induces frequent deglutition and acuteness of taste, and causes eructations, increase of appetite, and warmth in the epigastrium. One or two hours after drinking even small quantities of the water, the flow of urine is increased and its chemical composition, according to Dr Braun, altered, inasmuch as more considerable quantities of chloride of sodium, uric acid, and urea are eliminated than is the case if corresponding quantities of ordinary water are drunk. The absorption of the chloride of sodium is facilitated by the high temperature of the water, and the action of the bowel is therefore rather diminished than increased, especially if only a small quantity of the water is drunk.

After the repeated use of small doses of this water, digestion is much promoted. If somewhat larger quantities, such as twenty-four ounces of the water are taken, there is a more considerable effect upon the bowels, especially if the water is allowed to cool previous to drinking. The secretions of all the mucous membranes are augmented — the faeces become green, more fluid, and richer in chloride of sodium and in biliary constituents—the secretion of the Schneiderian membrane, of the salivary glands, and the mucous membrane of the lungs is increased — menstruation becomes more abundant, and ensues earlier than otherwise — lacteal secretion is also promoted, the milk becomes thinner and contains more chloride of sodium — perspiration is increased, but does not contain more chloride of sodium than before — the pulse is accelerated — congestions towards the head occur in many persons — the weight of the body is sometimes diminished, and eruptions appear on the skin. If the water has been used for six or eight weeks in succession, symptoms come on which indicate saturation of the system. Great aversion to the water is then experienced; the tongue becomes furred, thirst is troublesome, and there is a feeling of heaviness in the stomach, with other gastric symptoms. These are signs that the use of the water should be discontinued; or vomiting, diarrhoea, and congestion to the head and the chest, would follow. If very large doses are taken, as from twenty-four to thirty-six ounces per

diem, the purgative effects of the chloride of sodium are no longer counterbalanced by the high temperature of the water: diarrhoea ensues, and the faeces are found to contain much tablesalt. The secretion of urine is, in this case, scarcely augmented, nor is the elimination of chloride of sodium, uric acid, and urea increased. If the use of such large doses as I have just mentioned, is continued, inflammation of the stomach and the intestines is caused, and the weight of the body is much diminished.

The effects of the same water upon the quantity and composition of the urine have recently been elaborately investigated by Drs Neubauer and Genth. They first determined the average quantity of the urinary water and solids under ordinary circumstances, for five and eight days respectively; they then took baths of the mineral water, of a temperature of 95°, for five consecutive days, and again examined the urine during that time. Finally, for eight days, they took baths of mineral water as above, and also drank a certain quantity of Kochbrunnen, viz. four hundred and five hundred cubic centimètres respectively, the temperature of the water being almost as high as that of the spring itself. The following results were arrived at: — the quantity of urine, which was 1414 in the one, and 1252 in the other, rose during the days in which mineral baths alone were taken, to 1707 in the one, and to 1305 in the other. At the time of simultaneous drinking and bathing, the quantity rose to 2050 in the one, and to 1547 in the other. The urea rose in one from 33 to

39.6 and 42.8 grains; uric acid varied from 0.493 to 0.6 and 0.506; sulphuric acid rose from 1.93 to 2.4 and 2.405; phosphoric acid from 2.587 to 3.453 and 3.404; chloride of sodium from 14.742 to 16.467 and 23.678; lime from 0.188 to 0.248 and 0.314; magnesia from 0.206 to 0.213 and 0.208; chloride of ammonium from 2.072 to 2.344 and 2.722. The weight of the body did not undergo any remarkable changes during the whole time.

The effects of the water of Baden-Baden upon the metamorphosis of matter are only imperfectly known. This Spa is, on the whole, more a resort for healthy persons in search of pleasure and relaxation, than a refuge for patients; besides which the water at that place, if used for medical purposes, is scarcely ever administered in its natural state. The chief action of the water when taken as it is, seems to be to induce constipation, which is probably due to the high temperature of the springs, and the use of aperient medicines therefore becomes necessary. The Physicians at Baden-Baden are in the habit of adding to it Carlsbad salt, bicarbonate of soda, iodide of potassium, lactate of iron and other medicines. The thermal water used for bathing is generally mixed with Kreuznach mother-lye.

Amongst the tepid muriated waters, those of Mondorf, Canstatt, and Soden, are of the greatest importance. The springs of Mondorf contain, besides chloride of sodium, a certain amount of bromide of magnesium, whereby their effects are modified. At Soden,

there are two springs in which a comparatively small amount of chloride of sodium and carbonate of protoxide of iron is found; and two others containing a considerable quantity of both these substances. The former of these act chiefly upon the mucous membrane of the respiratory organs, and the latter have a powerful effect upon intestinal secretion and abdominal circulation. The action of the springs of Canstatt is modified by a certain quantity of sulphates contained in them; but no exact physiological researches have as yet been made to show the effects produced by the last mentioned Spas on healthy persons.

6. BRINES.

Brines contain a very large amount of chloride of sodium which is extracted from them for commercial purposes. They are only seldom internally administered, and if so used, care must be taken that they are sufficiently diluted with fresh water. Brine-baths, on the contrary, are most extensively used, and their action upon the system has of late been investigated by several observers.

Dr Lehmann has made a number of experiments concerning the action of the thermal brine-baths of Rehme. He found that by their use the insensible perspiration by the skin and lungs became increased, while it was diminished by ordinary water-baths. The excretion of urinary water and solids, especially urea, was also augmented; although the increase was not so consider-

able as is the case after ordinary water-baths. The elimination of phosphate of lime, which is augmented by the ordinary water-bath, was diminished by the thermal brine-bath. The loss of body-weight after the brine-bath was not so considerable as after ordinary baths. After brine-baths have been taken for several weeks successively, nutrition is improved and the body-weight augmented. An increase, especially of the progressive metamorphosis of matter, and of diaphoresis, are therefore the chief effects of the brine-baths.

According to Dr Alfter, the thermal brine-baths have a powerful action in stirring up the nervous and muscular system. The skin gains a fresher and healthier appearance; the appetite is increased, the bowels are more easily voided, the abdomen and the chest become expanded, the pulse rises, the sexual desire becomes stronger, the muscles firmer, and the mind more settled and cheerful. But if the use of the baths is continued too long, febrile symptoms, emaciation, pain in the back &c., are apt to follow.

Dr Lehmann has also made a few experiments on the physiological action of the brine vapour-baths of Rehme. The vapour-bath is formed by spontaneous evaporation of the brine, and it is generally given at a temperature of 76°. It acts chiefly as a diuretic, and chloride of sodium and the earthy phosphates are increased by its use.

Professor Beneke, of Marburg, has made a series of very laborious researches on the physiological effects of the brine-springs of Nauheim, both internally and

externally administered*. His experiments were made in April and September, and were continued each time for three weeks, and on three different persons. In the first series of experiments, Professor Beneke ascertained the normal condition of the secretions and excretions, and the weight of the body, for six consecutive days; in the second week the action of the ordinary warm brine-bath, and in the third week the action of the brine-bath with the addition of mother-lye to it, was determined. In the second series of experiments the first week was employed as above, the second being devoted to the investigation of the effects of the internal administration of the Curbrunnen, the principal mineral spring of Nauheim; and in the third week the action of both the Curbrunnen and the brine-bath simultaneously used, was studied. Care was taken that during the whole time the habits of the persons experimented upon, such as the quality and quantity of food and drink, the amount of exercise in the open air, work, sleep &c. were rendered as uniform as possible.

The ordinary warm brine-bath of a temperature of 88°, and of half an hour's duration, was found to slightly accelerate the general metamorphosis of matter. The whole of the excretions amounted in one person to 40,980 grains per diem during the first week, and rose to 42,900 grains daily in the second week. In another person it rose from 41,640 to 45,390; and in a

* Ueber Nauheims Soolthermen und deren Wirkungen auf den gesunden und kranken menschlichen Organismus. Marburg 1859.

third, from 42,960 to 46,485. The surplus therefore amounted to 1920, 3750, and 3525 grains in the three cases. The body-weight was found to decrease in the morning, during the whole period over which the experiments extended; this decrease was however more considerable in the second week, when brine-baths were taken. In one person it was 2844 in the first, and 4207 in the second week; in another the numbers were 5580 and 9042; and in a third 3840 and 6195. The body-weight again increased in the afternoon, and there was a slight acceleration of the metamorphosis of matter at night. The increased waste of tissue caused increased appetite, especially towards onon. The bowels did not seem to be much affected. Perspiration was only augmented if the temperature of the atmosphere was high. The elimination of urinary water and urea was slightly increased; phosphoric acid was diminished. There were slight and irregular variations in the quantity of uric acid, chloride of sodium, and sulphuric acid. The rate of pulsation was at first retarded and afterwards accelerated. In the afternoons of the days on which brine-baths were taken, the pulse was considerably raised.

Prof. Beneke has satisfied himself that no absorption of water or salines by the skin takes place in the bath. Chloride of sodium is not absorbed, for the quantity of this substance in the urine was not at all augmented after the bath. Bicarbonate of lime cannot be absorbed as, by the escape of carbonic acid, it is transformed into carbonate of lime, and thereby rendered insoluble.

Water is not absorbed, because there is no constant increase of body-weight after the bath. The primary effects of the brine-bath can, therefore, be only due to its influence upon the cutaneous nerves.

2. If a quantity of mother-lye varying from twelve to eighteen pounds was added to the bath, the cutaneous nerves were much more powerfully stimulated than by a simple brine-bath. The metamorphosis of matter was accelerated during the morning, and retarded in the afternoon. The whole amount of matter excreted during the day rose in one person from 40,980 to 42,375; in another from 41,640 to 44,505; and in the third person from 42,960 to 48,330. The insensible perspiration by the skin and the lungs was diminished; and the rate of respiration retarded. There was no constant effect upon the pulse, the rate of which was at times increased, and at other times diminished. The appetite was augmented. The quantity of urinary water and urea was increased, and that of phosphoric acid not diminished. Sulphuric acid was slightly increased; uric acid and chloride of sodium were, on the other hand, diminished. A feeling of weariness and disinclination to work was also induced. Professor Beneke also satisfied himself that there was no absorption of any ingredients of the mother-lye by the skin; but that the effect of the bath was exclusively due to its influence upon the cutaneous nerves.

3. A third series of experiments was undertaken in order to determine the effects of the internal use of

the Curbrunnen. Three hundred cubic centimètres of the mineral water, diluted with the same quantity of fresh water, caused the body-weight to increase. The excretions were increased in the morning and afternoon, and diminished during the night. If the temperature of the atmosphere was high, the insensible perspiration by the lungs and the skin was more increased; while in cold weather the kidneys acted more freely. The elimination of faeces was augmented. The quantity of urea and sulphuric acid was increased, that of phosphoric acid and uric acid was scarcely, if at all, altered. The rate of pulsation remained the same, but that of respiration was diminished.

4. A fourth series of researches concerned the effects of the simultaneous administration of Curbrunnen water and the simple brine-bath, which gave the following results:—the appetite increased, especially in the afternoon, and provided it was indulged, the body-weight was also augmented; the excretions were considerably increased in the morning, and diminished in the afternoon; and the rate of pulsation and respiration was reduced, especially if the bath was taken some time after a meal.—

The effects of warm brine-baths of a temperature of 104°, and of half an hour's duration, have been investigated by Dr Valentiner, of Pyrmont. He did not observe any contractions of the nipples and the scrotum, but the face became red, and a pleasant sensation of warmth was felt at first, which was succeeded by a chill—the temperature in the mouth fell 1°—the pulse was retarded

by six beats, and the respiration did not undergo any constant variations—the amount of urine passed before the bath was 35 cubic centimètres, during the bath it was 58, and after the bath 89 cubic centimètres—the quantity of urinary water increased by $8^3/_4$ per cent, and the acidity of the urine and the quantity of urea were diminished, while on the other hand, sulphuric acid, phosphoric acid, and chloride of sodium were increased.

Sea-baths.

The physiological action of sea-baths is due to the combined effects of the sea-water, its low temperature, the shock of the waves, and the sea-air.

The peculiarities of sea-air are increased density, considerable moisture, abundance of saline particles, ozone, and a more equal temperature. The proportion of nitrogen and oxygen in sea-air is not different from that of land-air; but as the density of the atmosphere is most considerable at the level of the sea, the same volume of air contains more oxygen at the seaside than in inland places. M. Verhaeghe, of Ostend, has found that sea-air contains less carbonic acid than land-air; the proportion being $^{2\cdot5}/_{10000}$ths in the former, and $^{4\text{ to }5}/_{10,000}$ths in the latter. Regarding moisture, Graefe noticed that a cubic foot of sea-air at Norderney contained 6.25 grains of aqueous vapour, and that the same quantity of air in Berlin contained in the same month only 4.77 grains. The presence of appreciable quantities of iodine and bromine in sea-air has not yet

been satisfactorily proved; its odour, however, would certainly lead us to infer the presence in it of a certain amount of bromine. Particles of chloride of sodium and hydrochloric acid have by many observers been discovered in sea-air.

The influence of a mere residence at the sea-side upon the metamorphosis of matter in persons coming from inland places, has been chiefly investigated by Professor Beneke*, Dr Wiedasch**, and Dr Abbotts Smith***. Professor Beneke found that, under such circumstances, the quantity of urinary water rose from 1377 to 1469 cubic centimètres, and that of urea from 366 to 413 grains. Uric acid fell from 6.27 to 3.21 grains; sulphuric acid rose from 21.06 to 25.21; phosphoric acid fell from 43.39 to 35.68, while the chlorides rose from 153 to 159. At the same time the appetite increased, and the body gained weight to the average amount of 892 grains per diem. Retrogressive and progressive metamorphosis would therefore seem to be equally increased by a residence at the sea-side. Experience has shown that, if scrofulous children are sent there, the quantity of uric acid and earthy phosphates eliminated by the urine, undergoes a most remarkable diminution.

By sea-bathing the metamorphosis of matter is still further accelerated. Dr Beneke found that, after a sea-bath, the perspiration by the skin is considerably increased, the excretion of urinary water, chloride of

* Ueber die Wirkungen des Nordseebades. Göttingen 1855.

** Das Nordseebad etc. Hannover 1858.

*** Eastbourne as a resort for invalids. London 1861.

sodium and phosphates diminished, and the body gains, on an average, 855 grains per diem. The physiological effects of the bath are most striking in the hours immediately following it. Professor Virchow found that the rate of pulsation was increased by exercise in the morning, while that of respiration was somewhat reduced, especially when the weather was cold. During the bath the number of inspirations was augmented, and the rate of the pulse was sometimes lessened and sometimes increased. Both the pulse and the respiration generally returned to their normal standard in from half an hour to one hour after the bath, and were slightly accelerated during the afternoon and the evening.

The primary effects of sea-baths are, according to the same observer, the following:—the blood is repelled from the peripheral parts to the internal organs, whereby the function of these latter is disturbed. Loss of power is felt in the motor, and a diminution of sensibility in the sentient nerves. The muscles are less excitable than under ordinary circumstances. The secretion of the skin and of the internal organs is considerably diminished, the body being nearly in the same condition as that of an animal whose skin has been covered with varnish. The production of animal heat is lessened. As secondary effects of sea-baths, certain changes of animal temperature which have already been noticed (p. 167—169), and an increase of appetite and body-weight, may be mentioned.

7. MURIATED LITHIA WATERS.

The salts of lithia, into the pharmaceutical properties of which M. Lipowitz and Mr Alexander Ure were the first to inquire, have recently been prominently brought under the notice of the medical Profession by Dr Garrod who recommends them in cases of uric acid diathesis connected with gravel, and in cases of chronic gout. This recommendation is based upon the fact that lithia possesses a great affinity to uric acid, and that the urate of lithia is the most soluble of all the urates. Mr Ure has found that a solution of one grain of carbonate of lithia in one ounce of distilled water, at a temperature of 90°, dissolves from two to three grains of uric acid, a much larger quantity than is dissolved by carbonate of soda or potash. The same Surgeon has proposed the use of the carbonate of lithia as an injection into the bladder, for the purpose of dissolving urinary calculi; and has found that a human calculus which was composed of uric acid with alternate layers of oxalate of lime, when placed in a solution of four grains of carbonate of lithia in one ounce of distilled water, and steadily maintained at a temperature of about 98° during five consecutive hours, lost five grains in weight.

Dr Garrod has shown that the urate is even more soluble than the carbonate of lithia. When an excess of carbonate is boiled with water, the addition of uric acid causes it to dissolve, and biurate of lithia is formed. The same observer has experimented upon a meta-

carpal bone, the phalangeal extremity of which was completely infiltrated with gouty deposit of urate of soda. This was placed in a small glass and a few grains of carbonate of lithia added, and in the course of two or three days the whole deposit was dissolved without having been heated. On making comparative experiments with the carbonates of lithia, potash and soda, on a cartilage infiltrated with urate deposit, he found that the cartilage taken from the lithia solution forty-eight hours afterwards; had been restored to its normal condition; that from the potash was much acted upon; but that which had been submitted to the influence of the carbonate of soda, appeared unaltered.

The physiological effects of the muriated lithia waters of Baden-Baden are, according to Dr Ruef, as follows: — at first they promote digestion, and a feeling of well-being is induced; but after they have been taken for some time, and especially when in large doses, sickness, disposition to vomiting, and diarrhoea ensue, which in most cases gradually disappear, but which sometimes continue so long as the water is drunk. A constant effect is an increased elimination of urine, the amount of which is often doubled or even trebled; after some time it becomes turbid, and large quantities of a reddish sediment are deposited by it. In some patients profuse perspiration came on after from five to ten days, and continued so long as the water was drunk; in the case of a lady who had not freely perspired for years, this perspiration even continued two months after

the treatment was finished. It therefore appears that the water is a diuretic as well as a diaphoretic.

8. IODO-BROMATED MURIATED SPRINGS.

These springs, the most important amongst which are those of Kreuznach, Krankenheil, Wildegg, and Castrocaro, contain chiefly chloride of sodium, iodide of sodium, and bromide of magnesium.

It is probable that the small amount of iodine and bromine contained in the solid and liquid food taken daily, is necessary for the preservation of health. Where these substances are entirely wanting, certain diseases, such as bronchocele and others, are apt to follow. The natives ofIceland are in the habit of eating large quantities of sea-weeds which contain a considerable amount of iodine, without any unpleasant symptoms resulting therefrom.

When given internally, iodine as well as bromine are absorbed by the blood, and eliminated, chiefly by the saliva and the urine. They have also been found in the blood, the milk, perspiration, tears, synovia, the brain and spinal cord, the liver, spleen and other organs; but they have never yet been discovered in the faeces.

The effects of iodine and bromine differ considerably according to the preparation administered. Pure iodine and bromine when given internally, have a much more violent action than the iodide and bromide of potassium, sodium and magnesium. The former pro-

duce irritation and inflammation of the whole intestinal canal: and a salty taste, increased thirst and secretion of saliva, vomiting, purging, and pain in the abdomen are induced. Bromine, if absorbed into the general circulation, seems to exert a more powerful influence on the nervous system than iodine, as vertigo, sleepiness, sopor and similar symptoms frequently follow its use. Large doses may cause death, but four to five grains can be taken daily without danger to the system. If applied to the skin, iodine and bromine produce redness, heat, pricking, pain and eruptions; and if inhaled, inflammation of those parts of the mucous membrane with which they come in contact, is brought about. Small doses of iodine and bromine, regularly administered for a somewhat lengthened period, augment the secretion of saliva and alter its quality. They have also diuretic and aphrodisiac effects; they promote the menstrual discharge, and may excite abortion. The mucous membrane of the frontal sinus, of the nose, the conjunctiva, and the urethra, become irritated and inflamed, and fits of asthma sometimes follow, probably in consequence of an inflammatory swelling of the bronchial tubes. Other symptoms of iodism are depression and irritation of the centres of the nervous system, furunculi and various other eruptions. At the same time the lymphatic system is powerfully affected, and the retrogressive metamorphosis of fat and muscular tissue accelerated. In certain instances the mammae, testicles and tonsils have become atrophied by the too prolonged use of iodine or bromine, and pal-

pitations of the heart, and haemoptysis have also frequently been observed to follow.

Very little is at present known concerning the effects of the iodo-bromated muriated waters upon the general metamorphosis of matter. The influence of such waters depends chiefly upon the proportion of iodine and bromine to the quantity of other salines found in them. There are some springs which contain a comparatively large amount of iodide of sodium and bromide of magnesium, but at the same time so much chloride of sodium that they require to be considerably diluted before they can be used internally, whereby the production of the specific effects of iodine and bromine is retarded; on the other hand, such waters as contain little iodine or bromine as well as only a small quantity of salines, and which can therefore be taken as they are, will more readily bring about the peculiar effects of iodine and bromine.

If baths of these waters are taken, neither iodine nor bromine are absorbed by the skin, nor does this result even if mother-lye is added to the bath.

According to Wetzler and Ittinger, the moderate use of the Adelheidsquelle, of Heilbronn, does not produce any unpleasant symptoms. It never causes emaciation; on the contrary, the muscles become firmer and more strongly developed. If drunk by women while nursing, the lacteal secretion does not become diminished.

Iodo-bromated waters augment the secretion of saliva and the appetite, and stimulate the mucous mem-

branes generally. If they at the same time contain a certain amount of sulphate of soda, as do the waters of Castrocaro, the bowels are likewise acted upon; and if large quantities of the waters are taken, diuresis is much increased. A too prolonged use of the iodo-bromated waters may, however, produce the symptoms of iodism described above.

9. EARTHY SPRINGS.

The chief contents of these springs, the most important of which are those of Leuk, Bath, and Baden in Switzerland, are sulphate and carbonate of lime, to which is added a certain amount of chloride of calcium, carbonic acid, and chloride of sodium.

Lime which in the human body is generally bound to phosphoric acid, plays a most important part in the economy. The bones of the adult contain two pounds of this substance which also enters largely into the composition of the blood, saliva, semen, nerves, muscles, and other organs. If lime is withdrawn from the food, the bones become softened. During pregnancy when the foetus consumes a large quantity of the lime contained in the blood of the mother, the urine contains very little of it, and if fractures take place at that period, they heal with difficulty. Lime is excreted by the urine as carbonate and phosphate, and its elimination by the kidneys seems to be increased in certain diseases of the nervous system.

No exact researches have as yet been made con-

cerning the physiological effects of earthy springs. The water of Leuk produces a feeling of warmth in the stomach and increases the appetite and the action of the bowels, the kidneys and the skin. In some persons however, flatulency, loss of appetite, indigestion, and congestion to the head, are observed after the use of this water. The action of earthy waters on the skin and the mucous membranes seems to be of an exsiccating and astringent character. According to Buchheim, this is due to a chemical combination of lime with fatty acid, whereby an insoluble compound is formed which impedes secretion.

The Bath water is slightly saline and rather bitter; it also tastes a little of iron, but this disappears after the water has become cold. If drunk, it accelerates the pulse, promotes digestion and the secretion of the urine. Constipation sometimes follows the use of small doses, while large doses, on the contrary, cause diarrhoea. In some persons even small quantities of this water produce fulness in the head, sleepiness, vertigo, and pressure in the epigastrium. The water being very hard, baths of it cause a rather unpleasant sensation in the skin. Persons who remain in the bath for several hours daily, become stout and strong, and are generally long-lived.

Small doses of the water of Baden, in Switzerland, internally administered, act upon the kidneys; large doses increase perspiration and often cause diarrhoea; but in irritable persons constipation may ensue, which is generally accompanied by flatulency, pressure in the

epigastrium, and fulness in the head. The effects of baths of this water are very different according to their temperature, and to the length of time the patient remains in them. M. Minnich mentions that a common effect of the baths is, to impart a saline taste to the saliva. If the use of the hot baths is continued for several weeks, febrile symptoms are not unfrequently observed; the tongue becomes coated, constipation or diarrhoea ensue, the appetite is diminished or disappears entirely, sleep is disturbed, and general indisposition is complained of. Old rheumatic and gouty pains are renewed and increased, cicatrices become more sensitive, and ulcers secrete more largely. Sediments are formed by the urine and copious perspiration ensues. If the patients remain in the bath a considerable time, as five hours and more, every day for three or more weeks consecutively, an eruption appears on the skin, which is very similar to those previously described as following the use of the baths of Leuk and Schinznach (pp. 176–179).

10. INDIFFERENT THERMAL SPRINGS.

The indifferent thermal waters contain only a few grains of salines, and are distinguished by their high temperature. The water is limpid, colourless, or slightly blue, devoid of odour, and of any physical peculiarities different from those of ordinary warm water. Nevertheless, these Spas possess very remarkable physiological and therapeutical properties. Baths of these waters

promote the action of the skin and excite the peripheral nerves, and by reflex action from these, the nervous centres are affected, especially if they are weakened. Effects of the latter kind are chiefly caused by such thermal springs as issue at high altitudes; and it is probable that the diluted air and the diminished pressure which exists in those regions, essentially contributes to the effects of the waters.

The thermal springs of Gastein are chiefly used for bathing. If the water is taken internally, it produces constipation in some, and purging in other persons. Large quantities cause vertigo. The observations on the physiological effects of the baths are for the most part of only little value, because the temperature of the water used for bathing has not been accurately noticed. On first entering the bath, the sensation produced is not at all pleasant; the water feels rather astringent, the skin seems to shrink, and on leaving the bath, it does not feel so supple as is the case after other baths. M. Vivenot remarks that by these baths the pulse is much retarded, except in irritable persons, and remains so for several hours, or even for the whole of the day; and it is only accelerated if "crises" are approaching or have already appeared. M. Schlesinger found that after a bath of half an hour's duration, the pulse fell from fifteen to twenty beats, and the rate of respiration was also somewhat diminished. Eble, on the other hand, remarks that the most striking effect of the bath is acceleration of the pulse, which also becomes fuller and harder; he found that it rose fifteen beats during

the first twenty minutes he stayed in the bath. Dr Granville who took a bath of 96° and remained in it for three quarters of an hour, found that the pulse became fuller. M. Streintz mentions as effects of the Gastein baths, acceleration of the pulse, and an increase of heat and muscular power. Snetiwy justly remarks that the pulse is only accelerated if the water is very hot; but that if the temperature is low, the pulse becomes retarded. The bath is not exciting, in the ordinary meaning of the term; for persons with habitus apoplecticus, heart-disease, and even hemiplegic patients shortly after a seizure, often bathe in Gastein water without any unpleasant consequences, but are on the contrary improved by it. Regarding the sexual function, the statements of the different observers are very contradictory. Some affirm that this is stimulated, while others assert that the contrary takes place.

The baths of Wildbad, in Würtemberg, are chiefly taken in so-called piscines, or swimming-baths. These are large reservoirs the soil of which is covered with fine sand, through which the water rises from the depth at a temperature just suitable for bathing. It is therefore not necessary to heat or cool the water, and a constant renewal of it is also rendered easy. Bubbles of nitrogen in which the Wildbad water is very rich, continually glide along the surface of the body, and produce a sort of titillation which is by no means unpleasant. If the stay in the bath is too prolonged, weariness, fatigue, vertigo, headache, and febrile symptoms are apt to follow.

The water of Warmbrunn, in Silesia, is also chiefly used for bathing. In some persons these baths do not seem to produce any striking effects whatever; in others the circulation becomes very much excited, and the nutrition improved. M. Adolph states that a critical eruption breaks out in many patients after a few days; but this is by no means the rule. If the water is drunk, its effects do not differ from those of ordinary warm water.

The springs of Pfäffers, in Switzerland, are used for drinking as well as for bathing. This water agrees very well with the stomach even of weak persons. The elimination of urine and perspiration is increased by its use, but it has no action on the bowels. Sickness and vomiting are scarcely ever observed if the water is drunk. The baths have different effects according to their temperature and duration. Thus they may restore sleep and retard the rate of pulsation; while, on the other hand, they may cause excitement, sleeplessness, and a quick pulse. After they have been used for some time, costiveness, loss of appetite, fulness in the head, and other unpleasant symptoms are observed which, however, generally disappear after a short time. Eruptions do not appear in the skin unless the bathing is continued for many hours every day; a mode of treatment which has now been almost entirely given up by the Physicians of Pfäffers.

The water of Schlangenbad, in Nassau, is almost exclusively used for bathing. It has a soft velvety feel if taken between the fingers, and imparts a most pleasur-

able sensation to the skin. 'It renders this exceedingly soft, supple and delicate, and is therefore extensively used by ladies, especially by those in a somewhat advanced age. Eruptions are scarcely ever caused, but the bath leaves a feeling of vigour and suppleness in the whole frame.

The symptoms produced by the thermal baths of Teplitz, in Bohemia, do not differ from those caused by ordinary warm baths, which have already been described.

The indifferent thermal springs of Pentecosa, in Upper Aragon, which contain a large amount of pure nitrogen, have a sedative action, when used for bathing. This water is also much taken internally, and is remarkable on account of the ease with which it is digested. Most of the patients drink twenty-five to thirty tumblersful of it per diem, without perceiving any unpleasant consequences. It is evident that such enormous quantities of water regularly ingested into the system for any lengthened time, must produce most powerful effects on the general metamorphosis of matter, but which have hitherto not been investigated.

The waters of Plombières, Tüffer, and other Spas of this class, do not produce any effects upon healthy persons different from those of ordinary warm water.

11. CHALYBEATES.

Iron is an important ingredient of the blood, a considerable quantity of it being contained in the haematine of the blood-globules. One pound of blood contains four grains of iron; which is also found in the spleen, the muscles, the hair, the pigment of the choroidea, the bones and cartilages, the faeces and the urine.

If small quantities of iron are internally administered, this substance is dissolved by the gastric juice, and is absorbed. M. Schroff has found that, if iron was taken for a prolonged period, it could sometimes be traced in the urine, and at other times not. If iron is taken by persons suffering from anaemia, and is not discovered in the urine, this is no proof that the iron has not been absorbed; it being probably retained in the blood, which in such persons contains an insufficient amount of this metal. The experiments of Messrs Andral and Gavarret, and Messrs Becquerel and Rodier, have shown that, by the internal use of iron, the formation of blood-globules is promoted. Thus in a case of anaemia, the quantity of globules rose, under the influence of this medication, from 46.6 to 95.7 parts.

Large quantities of iron are insoluble in the intestinal secretions, and are therefore eliminated by the bowels. In the lower part of the intestines, iron encounters sulphuretted hydrogen. A decomposition then takes place and sulphuret of iron is formed, which imparts a green colour to the faeces. If the use of iron is con-

tinued for a long time, digestion becomes imperfect; and loss of appetite, constipation, oppression on the chest, and other symptoms of disturbed nutrition follow. Iron causes an increased contraction of the capillary vessels, with all its consequences.

In chalybeate springs, the carbonate of protoxide of iron is generally accompanied by carbonic acid and carbonate of manganese, by which the effects of the iron are much modified. Waters of this kind are generally limpid and devoid of smell; they have an astringent taste which is, however, in the true acidulous chalybeates, entirely neutralised by the more pleasant taste of the carbonic acid. The physiological action of carbonic acid is in many respects similar to that of iron. By small quantities of both, digestion is promoted, the activity of the heart increased, and muscular power strengthened. Acidulous chalybeates constitute the ordinary drink of the inhabitants of the neighbourhood of Marienbad. M. Heidler has endeavoured to ascertain whether any deleterious effect was thereby produced, or not; and found that the people were, on the whole, strong and healthy; but that, if they suffered from inflammatory diseases of the chest and intestines and continued to drink the water, these diseases took a severe form.

Dr Valentiner has made some experiments on the physiological action of the acidulous chalybeates of Pyrmont. The water of the Trinkbrunnen, of that place, has an astringent taste, and produces at first a feeling of cold in the stomach, but this is soon succeeded by

a pleasant sensation of warmth. In irritable persons, sickness, vomiting, rigors, and cardialgia are sometimes induced. The appetite is increased, and constipation is more frequent than diarrhoea. After twenty to thirty ounces of the water have been taken, the faeces assume a greenish black colour, in consequence of the formation of sulphuret of iron. After the use of the Pyrmont water, iron is no doubt absorbed, but it has not yet been found in the urine. The kidneys are not much affected. If 570 cubic centimètres of the chalybeate, and 1309 cubic centimètres of fresh water were drunk, only 1797 cubic centimètres of urinary water were eliminated. The solid constituents of the urine were however slightly increased after the use of the water, especially the free acid, sulphuric acid and chloride of sodium, urea being scarcely at all augmented, and phosphoric acid being diminished. These changes in the quantity of solids continued for three days after the experiment.

The physiological effects of the saline chalybeates are due to the water, iron, carbonic acid, and the carbonate and sulphate of soda and lime. Experiments concerning their action in health have not yet been made.

12. SULPHUROUS WATERS.

Sulphur, sulphuretted hydrogen, and sulphurets of metals, are absorbed if internally administered. Wöhler discovered sulphuretted hydrogen in the urine of a dog

to whom he had given a drachm of sulphur. Autenrieth found that the blood of a cat, to which he had for some time administered sulphuret of potassium, blackened silver. If animals are placed into bags filled with sulphuretted hydrogen, the head alone excepted, death takes place in ten to twenty minutes; so that there can be no doubt that this gas is absorbed by the skin. The inhalation of sulphuretted hydrogen by the lungs is more quickly fatal, and small quantities of it are sufficient to destroy life. Birds die, if only one part of this gas is mixed with 1500 parts of air. The first symptoms of poisoning by sulphuretted hydrogen are: weakening of the heart's action, small and feeble pulse, and a sensation of weakness and exceeding fatigue. Small quantities of the gas stimulate the secretions of the mucous membrane of the eyes, the nose and the bronchial tubes; at the same time the skin becomes warmer. If it is dissolved in water and taken internally, the action of the bowels is increased.

The physiological effects of the sulphurous springs are widely different according to their temperature, and the other solid and gaseous ingredients contained in them. Sulphurous thermal springs considerably accelerate circulation. The waters of Eaux Bonnes, when taken internally, produce, according to Dr James, agitation, sleeplessness, and general excitement of the nervous system, the same as is caused by drinking very strong coffee. The power of the muscles appears increased, the complexion becomes florid, a sensation of heat in the pharynx, injection of the tonsils, altera-

tion of the voice, aphonia, and pain behind the sternum and between the shoulders are felt. In patients suffering from cough, this is increased and copious expectoration induced. Sometimes there is also increased appetite, constipation, and pain in the abdomen.

The waters of Saint-Sauveur, if used for bathing, produce a sedative effect upon the system. They contain a large quantity of barègine, which imparts an oily feel to the water. The waters of Barèges, on the other hand, are very exciting. They augment all secretions, and after a few days' use, produce febrile symptoms. In persons disposed to congestions, they may cause apoplexy.

Exact physiological researches on the effects of the cold and thermal sulphurous springs, internally and externally used, on the general metamorphosis of matter, are almost entirely wanting. The only observer who has made a few experiments on this subject, is Dr Böcker who was led to the conclusion that, after the use of such waters, the exhalation of carbonic acid by the lungs, and the elimination of uric acid by the kidneys, was increased.

CHAPTER VI.

THE THERAPEUTICAL USE OF MINERAL WATERS.

The Greeks appear to have been the first to use mineral waters as remedies for disease. For this we have the testimony of Aristotle, and the Pre-Homerian myth that Hercules had imparted power to the warm springs by bathing in them. Most of the thermal waters in which Greece is so rich, were, in fact, sacred to Hercules, and numerous "Herculean baths" existed of old in all parts of Greece, Sicily, and Italy. Hercules was likewise believed to be the originator of the douche, and on some ancient coins which were found near Himera, in Sicily, he is represented standing in a tub, with his broad chest exposed to a jet of water issuing from the mouth of a lion.

The oldest Greek Physicians had great faith in the curative powers of mineral waters, and when temples were erected to the God of Medicine, the priests of Aesculapius took care that these should be in close proximity to mineral springs. Places of this kind were not only destined for worship, but also for the cure of the sick; they were connected with medical schools, hospitals, theatres, and other places of amusement for convalescents, many of which might have rivalled the contrivances existing for such purposes in a time which continually boasts of its civilisation. The most remarkable of these was

the sacred grove of Aesculapius, near Nauplia, which was the constant resort of the sick and feeble from all parts of Greece, it being the birth-place of Aesculapius, and therefore reputed to possess special curative powers. Pausanias relates, that a great many columns existed in the enclosure, upon which were inscribed the names of those who had been cured there, as well as the nature of their maladies. Of the many edifices which existed in this grove, there are still to be seen the remains of a theatre in which, according to Dodwell, who visited it in the early part of this century, there were fifty-four pink marble seats in good preservation, and which were evidently contrived with the view of accommodating a feeble audience of convalescents. According to M. Landerer, who has recently made an analysis of the mineral waters of Nauplia, they contain chiefly chloride of sodium, carbonate of lime, and carbonic acid.

Philostratus, when speaking of Agamemnon's bath, near Smyrna, relates that at the time when the Greek army under Agamemnon was ravaging Mysia, it was engaged by Telephus near the river Caicus; a sanguinary battle ensued, in which many Greeks were killed and wounded: the latter were then directed to resort to the waters just mentioned to be cured, and they were all restored. At Hierapolis the springs flowed so copiously in antiquity that the city was full of natural baths, and the representation on medals of Apollo, the tutelar deity of the Hierapolitans, with Aesculapius and Hygiea, bears witness to the medicinal virtues pos-

sessed by the waters. Strabo mentions that they imparted a red colour to the roots of trees and shrubs, and that from the mixture of the juices of these with the water of the springs, a purple liquor was prepared which was used for dyeing wool.

Numerous fables were current in antiquity concerning the extraordinary effects of mineral waters. Several authors mention two springs which existed in Hestiaotis, in Thessaly; the first of which caused sheep to turn black, and the second changed them again to white; two in the island of Ceos, one of which made those who drank of it, stupid, while the other made them clever; two springs in Phrygia, one of which excited, and the other annihilated the sexual power; a spring near Susa, which caused the teeth to fall out; another near Clitorium, in Arcadia, which made the odour of wine insupportable to those who had once drunk of the water; the spring of Alysson, near Nonacris, which was a specific for hydrophobia; a spring in Chios, which caused insanity, and another in Magnesia, which improved the voice of singers. Herodotus mentions a spring in the country of the Ichthyophagi or fish-eaters, the water of which made the skin shine as if polished, and at the same time imparted to the bathers a perfume as of violets. This water was of such small specific gravity that pieces of wood and other light bodies did not float in it, but immediately sank to the bottom; it also possessed invigorating and life-prolonging powers, so that those who constantly bathed in it, lived beyond 120 years. Finally I will

mention the springs of Lethe and Mnemosyne, in Boeotia, the former of which, according to the ancients, gave oblivion, and the latter memory.

Perhaps it was such and similar fables related of the extraordinary effects of mineral springs, which, as the science of medicine advanced in Greece, made the medical Profession of that country averse to the therapeutical use of the waters. Hippocrates, in his work "de aëribus, aquis et regionibus s. locis" says that the saline, hard, and drying-up waters, are, generally speaking, unwholesome; although there might be a few constitutions and diseases in which they could do good. Springs which came from rocks, were indigestible, and the same was the case with such thermal waters as contained iron, copper, silver, gold, sulphur, alumina, asphalt, or nitre. These heated the system and dried up the juices; they did not easily pass out of the body, and caused constipation. Those persons who asserted that saline mineral waters readily passed off with the faeces, and even excited the action of the bowels, spoke in ignorance; for the waters mentioned had just the contrary effects.

Hippocrates and his immediate followers were the first to attempt a classification of mineral springs according to their chemical composition. They assumed five different kinds of waters, according as they contained either sulphur, alumina, bitumen, nitre, or salines. Mixed waters acted according to the peculiarity of the most prominent ingredient contained in them. In using them, caution was necessary on account of the vapours

which ascended from them, and which might do mischief to the head. If baths were used, the persons concerned should be only gradually immersed, and special caution was necessary in the employment of the douche.

Herodotus wrote a treatise on the Natural Remedies for Health and Disease, which is mentioned by Oribasius, but which is unfortunately lost. He gave special rules for the therapeutical use of the mineral waters, especially as to the time for which the baths should be continued.

The Jews in Palestine also used cold and hot mineral springs at a remote period for the cure of disease. Nothing of the kind, it is true, is mentioned in the Old Testament; we only hear in the Genesis that Anah, son of Zibeon, the Hivite, and father of Esau's wife, while feeding asses in the desert, discovered there some thermal springs; and in the second book of Kings, a well at Jericho is mentioned, "*where the water was* "*naught and the ground barren*"; but which was made wholesome by the prophet Elisha throwing salt into it. From the New Testament, however, we learn that thermal waters were extensively used by the Jews before Christ; and that "*a great multitude of impotent* "*folk, of blind, halt, and withered, lay in the porches* "*of the lake of Bethesda*" (which, in Hebrew, means House of Mercy, or Charité) "*by the sheep-market at* "*Jerusalem, waiting for the moving of the water*"; and that "*whosoever first after the troubling of the* "*water stepped in, was made whole of whatsoever dis-* "*ease he had.*" This water contained salines and iron;

it was of a reddish-brown colour, no doubt from a sediment of ochre; sulphur was also found in the mud, which may account for the curative effects only becoming fully apparent when the water was stirred up. The most important springs of Palestine, however, were those of Tiberias (now Tabareah), near the lake of Genezareth, of which we find mention made in the writings of Strabo, Pliny, and Josephus. This lake is fifteen miles long, and has, on account of its picturesque situation, been compared by modern travellers to Lake Leman. Both at the eastern extremity of the lake, and towards the South, there are sulphurous thermal springs, of a temperature varying from 86° to 130°. They contain sulphuretted hydrogen, sulphate of soda and iron, and are chiefly used in painful swellings, rheumatism, gout, palsy &c. A portico of granite and Egyptian marble which led from the town to the baths, was erected there by the Romans; this is now deserted and destroyed, but the springs themselves are even at the present time visited by patients coming not only from the neighbourhood but from all parts of Syria, and whose thanks-offerings are deposited on a wall, where an immense amount of relics of hair, nails, teeth, and rags of every kind and colour may be seen. Another famous bath of this kind existed in the neighbourhood of the Dead Sea, in the ancient country of the Edomites, which was known to the Greeks and Romans under the name of Calirrhoe (beautiful spring). This place is mentioned by Josephus, who, when speaking of Herod's sickness, says: "he not only hoped for re-

storation, but thought of the means to bring it about. He caused himself to be carried across the Jordan, and used the warm baths of Calirrhoe, which flow into the lake Asphaltites." The same is spoken of by Pliny, who says that on the South side of that lake there existed a warm spring of great virtue in restoring health.

The most extensive use of mineral waters was, however, made not only in Italy and Greece, but also in most other parts of the old world, at the time of the Roman Emperors. The most ancient bath on record in Italy, is that of the grotto of Cumae, in which the Sibyl gave her oracles. A remnant of this grotto, which is situated between Cumae and the lake of Avernus, is still in existence; and a spring rises there which contains carbonic acid, sulphuretted hydrogen, and bicarbonate of soda. Very old contrivances for bathing may also be found in Ischia, in the Lipari Isles, and in Syracuse. At first the Romans only bathed in cold water, and Hannibal was blamed by them for resting too long "in fomentis Campaniae virum alias indomitum "enervantibus"*. On their conquest of Greece, however, the Romans became acquainted with warm bathing which they soon learned to appreciate. One of the first who erected thermal baths in Rome, was Scipio Africanus. The fashion soon spread, and at the time of Columella and Ammianus Marcellinus, there was scarcely a village in Italy without such establishments. The most luxurious baths were erected by Titus, Dio-

* Seneca Epistol 1. 50.

cletian, Hadrian, Antoninus, and Caracalla. More attention was at the same time directed to natural hot springs, a great number of which were then found to exist in all parts of Italy; and Bajae, Puteoli, Stabiae, and Cumae, became the most fashionable watering places. A reaction took place at the time of Augustus, who was cured of a fever by the hydropathic treatment of Antonius Musa; cold water then became the rage, and even newly-born infants were immersed in it, a custom which still existed at the time of Galenus, by whom it was severely censured. But when Marcellus, son of Octavia, suddenly died after taking a cold bath, the predilection for cold water very much abated, and under the reign of Nero, hot baths were again generally preferred.

In the course of their warlike expeditions to other parts of Europe, and to Asia and Africa, the Roman Generals used to station their troops where they encountered hot springs, which had become almost a necessity for them; and large and comfortable bathing establishments were erected at most such places. The Romans discovered a great many of the most important thermal waters of France, England, Germany, Spain, Portugal, Belgium, Pannonia, Transylvania, and even Africa. Amongst those most used by them I merely mention Aix in Savoy (Aquae Allobrogorum s. Gratianae), Acqui in Montferrat (Aquae Statiellae), Baden in Switzerland (Aquae Turicorum), Baden-Baden (Thermae Aureliae), Baden near Vienna (Aquae Noricae), Bath (Aquae calidae, sudatae, Solis), Wies-

baden (Aquae Mattiacae), Aix-la-Chapelle (Aquis granum s. Aquae Granenses), Spa in Belgium (Aquae ad civitatem Tungriam), Aix in Provence (Aquae Sextiae), Bagnères de Luchon (Aquae Convenarum), Bagnères de Bigorre (Vicus aquensis), Constantine (Aquae Tibilitanae), and many others. Mr Tristram, in his recent work on the great Sahara, informs us that on the eastern extremity of the desert, in the oasis of El Kantara, there exist the ruins of a Roman town and thermal baths, near a natural basin which receives the contents of a hot spring, and which had no doubt decided the selection of the site.

Much progress in the knowledge of the natural history and the curative powers of mineral waters, was not made by the Romans. Vitruvius remarked that the water of thermal springs had originally no peculiar virtues, but that certain substances in the interior of the earth were boiled by the water, which thus became impregnated with its most active ingredients. Sulphurous waters therefore restored the energy of the nerves, and dried up the deteriorated juices. Water containing alumina was useful in paralysis, and in atony of the bloodvessels. Bituminous water cleared the system of internal disorders. Nitrous water purified the abdomen, and diminished struma. Many springs issued at places, where metals such as gold, silver, iron, copper and lead were found; springs of this kind were however very dangerous, as they hardened and contracted the nerves and vessels, and caused gout and nervous diseases, and it was for this reason that the people of

Athens, where such waters were found in abundance, were affected with podagra.

Pliny mentions a very large number of mineral springs in all parts of Europe. He speaks especially of the waters of Bajae, which were so hot that they were used for heating cold baths; of the springs of Puteoli, which were believed to be a specific remedy for diseases of the eye; of the sulphurous waters of Albula near Rome; of the Thespic spring in Boeotia, which made women fertile; of the spring of Linus, in Arcadia, which prevented abortion; and of the hot springs of Mattiaci (Wiesbaden), which cured rheumatism.

Galenus gave as little attention to mineral waters as Hippocrates had done, although there were several mineral springs famous for their curative powers, near his native city of Pergamus, and he must have been acquainted with a large number of them in Italy, Greece, Macedonia, and other countries. He only mentions the aqua Albula, near Rome, which according to him may be useful in diarrhoea and obstinate wounds. He scarcely ever advised bathing in mineral waters, which he believed dangerous on account of the foreign ingredients contained in them; he said that they were heating and exsiccating, and either contracted the vessels or irritated the skin by their acidity. He therefore believed bathing in pure warm water preferable; but thought that in certain cases of dropsy, saline, nitrous, sulphurous and aluminous waters, might be drunk with advantage.

Most disciples of Galenus' merely repeated the doc-

trines of their master, and only a few of them took original views of the subject. Amongst these latter was Caelius Aurelianus who practised at the end of the second century, and who recommended mineral waters for a number of diseases. Patients suffering from paralysis after apoplexy, were sent by him to the thermal baths of Padua and Siena; such as complained of torpidity and blennorrhoea, were advised to use the Albula, and for stone in the bladder he prescribed the alkaline saline waters of Ischia. Antyllus, a Physician of the third century A. C., stated that the curative effects of the mineral water baths were much greater than those of ordinary baths. He found that nitrous and muriated waters were good for rheumatic affections of the head and the chest, and for atony of the stomach and oedematous swellings. Aluminous waters proved useful in haemorrhage, haemorrhoids, vomiting, and habitual tendency to miscarriages. Sulphurous springs calmed irritation of the nerves and dissolved obstructions, but at the same time weakened digestion. Bituminous waters caused congestions to the head and disturbances of the organs of special sense; they heated the womb, the bladder, and the large intestines. Copper springs were useful in affections of the mouth, the tonsils, uvula, and the eyes; while chalybeates cured atony of the stomach and the spleen.

With the decadence of the Roman Empire, the use of mineral springs also diminished. The buildings were left unrepaired, or were destroyed by the invading Barbarians, and at last only the neighbouring poor

continued to frequent them. The vapour-baths in the neighbourhood of Naples were special favourites with the people, to the great annoyance it is said of the doctors of Salerno, who were mortified to see ruined Bajae preferred to their prescriptions. The disuse of mineral waters was still further accelerated by the invectives of the priests who denounced the warm bath as sinful. Augustin, in his "Rules", only permitted bathing once a month; and Hieronymus entirely forbade it to the adult.

The Germans appear to have been, from time immemorial, much in the habit of bathing in their numerous rivers and lakes; and Caesar, Tacitus and Herodian mention, that they never took any but cold baths; while the aboriginal inhabitants of France, England and Ireland preferred hot springs. These latter were accustomed to carry their sick to the "holy wells" which were also resorted to from time to time by the inhabitants generally. At a later period the example of Charlemagne did much towards rendering the use of thermal waters fashionable in Germany: he had a great predilection for the hot sulphurous springs of Aix-la-Chapelle (800), and Eginhardt relates that sometimes more than a hundred persons bathed in them at the same time. But it was especially at the time of the Crusades, when the western nations became acquainted with the habits of the East, that the use of the warm bath became general. Where Roman buildings still existed, these were again resorted to; new establishments, however, were only erected at such places as were

patronised by crowned heads, such as the thermal springs of Wildbad, by Count Eberhard of Würtemberg (1367); Wiesbaden, by Adolphus von Nassau; Gastein, by Frederick of Austria; Carlsbad, by the Emperor Charles IV (1358), and Warmbrunn, by the Duke Boleslaus Crispus (1115). In Spain, thermal baths flourished under the Empire of the Moors, who like the Romans, everywhere erected magnificent buildings for the convenience of patients and visitors and they were strongly recommended by Rhases, Avicenna, Abulcases, and other eminent Arabian Physicians. During the middle ages a literature on mineral waters can scarcely be said to have existed, nor were there any theories of their nature and action; unless we should be inclined to adduce as such the statement of Origines, that thermal waters were tears wept by the fallen angels, and that their heat was due to the impetuosity of winds.

With the renaissance of the sciences, an extensive literature on this subject sprang up; the founder of which was the learned monk Clement of Gratz (1495). Conclusions regarding their nature were drawn by him from their taste. Such as had no taste, were believed to be simple; others were supposed to be mixed waters. If the taste was saline, the water was thought to come from the sea; if bitter, the presence of an unmatured metal, or of nitre, was supposed; if it had a pungent taste, brass and copper must be the cause; if sweet, the water contained alumina; if astringent, iron; and if fatty, sulphur. After some time, however, rude

chemical experiments on the composition of the springs were made. The water was allowed to evaporate, and the deposit which remained, was then subjected to the action of fire. Everything which was consumed by this, was declared to be nitre; that which was soluble and became red, vitriol; and if insoluble in water, lead. Thermometers being unknown at that time, the temperature of the springs was determined by the impression made by the water on the hand. The importance of mineral waters as curative agents in those times can scarcely be too highly estimated, if we consider the miserable state of medicine at that period; and that they were, without exception, the most effective and safest means of curing disease. The use of the waters, especially thermals, then became widely spread. Amongst others, the Johannesbrunnen, of Warmbrunn, in Silesia, was in great repute. This was dedicated to St. John the Baptist; and every year, on the feast-day of that Saint, thousands of pilgrims crowded there to recover their health by a draught at the spring; a custom which has only fallen into disuse in the beginning of this century. Caspar Hoffmann, who was Physician to the Elector of Brandenburg, says of the springs of Warmbrunn: "I have myself seen men and women who had lost the "use of their limbs, carried to these waters, and who "after some days' use of them, began to walk about "with a stick, and were at last able to do so without "any support whatever". In the 16th century the doctors of Breslau advised their patients to go and drink of this water, in consequence of which podagra and

sciatica were discharged by the faeces and the urine. After some time the waters were not only taken where they issued, but were also exported, in the so-called Transylvanian mugs, which, after having been carefully filled, were closed with wax and parchment.

The history of a more accurate knowledge of the constitution of mineral waters, is identical with that of chemistry. A great step in advance was made by Van Helmont who, in 1648, discovered the alkalies and fixed air. The "wild spirits" of Paracelsus, the "mineral spirits" of Tabernaemontanus, were then found to be a gas which is now familiar to us under the name of carbonic acid. A large number of chemical reagents was soon afterwards discovered by the Hon. Robert Boyle (1685). He found that all acids imparted a red colour to syrup of violets; that nitrate of silver was precipitated by tablesalt, arsenic by sulphuretted hydrogen, iron and other metals by tincture of gall-apples &c. About the same time, Dominique Duclos, Physician to Louis XIV, made the first analysis of the more important mineral waters of France. To this he was instigated by the youthful Academy of Sciences, which had just then been founded. In 1698, Dr John Floyer published an important work ("Inquisitio in usum and abusum balneorum Angliae calidorum, frigidorum et temperatorum.") which was written with the ostensible purpose of recommending the waters of Buxton, but was far above the average of most pamphlets of this kind. He gave a very accurate description of the dif-

ferent effects produced by warm and cold baths, and recommended the re-introduction of the latter as used by the ancients, for hardening and invigorating the body, preventing rickets and eruptions of the skin, and for the cure of many complaints. He succeeded in reviving their use in England; while at the same time, Signor Todaro, of Naples, induced the Italians to employ cold water for the prevention and treatment of disease. It is a singular fact that in the works of Sydenham no mention is made either of baths or of mineral waters; and this great Physician seems therefore to have shared the opinions of Hippocrates and Galenus with regard to them.

In the commencement of the eighteenth century, Frederick Hofmann, Professor of Medicine at the University of Halle, and one of the most eminent Physicians of his time, added most largely to our knowledge in this respect. He considerably improved the method of analysing the waters, and was the first to distinguish sulphate of magnesia from other sulphates; he denied that gold was contained in mineral waters; he combated the erroneous opinion which was then prevalent, that all mineral waters were acidulous, and he objected to the proceeding which was often resorted to at that time, of boiling the water before it was drunk, by which, according him, the best spring might be made similar to ordinary water. He analysed chiefly the waters of Carlsbad, Ems, Sedlitz, Halle, Aix-la-Chapelle, Altwasser and others; and he also recommended the manufacture of artificial

mineral waters in imitation of the natural ones, and their use by such persons as were unable to go to the Spas. He distinguished alkaline waters, thermal springs, chalybeates, bitter-waters, lime-waters, and such as contained scarcely any foreign ingredients. Concerning the therapeutical use of mineral waters, he remarked that if we wished to prescribe them with benefit to patients, it was necessary to be acquainted both with the diseases and the waters; but they were unfortunately often ordered by persons who knew neither the one nor the other. By many they were considered to act as charms, and the most absurd stories were circulated respecting them; while others again thought them dangerous, and only applicable in extreme cases. Professor Hofmann also strongly denounced the drinking of immoderate quantities of the waters, such as twelve quarts of Carlsbad Sprudel per diem; and said it was not at all necessary to begin the cure with drastic purgatives, as was generally done. If the water itself purged, no other cathartic was required; but if it did not purge, mild aperients, such as manna, rhubarb &c. were preferable. He also remarked that there was no reason why mineral waters should not be taken by women during menstruation.

For making artificial mineral waters, Frederick Hofmann laid down the following rules: to make a chalybeate, a small quantity of very fine ochre should be boiled in a glass; to make a saline chalybeate, tablesalt should be added to the decoction just mentioned. For making acidulous chalybeates, sal tartari and diluted

sulphuric acid should be added to the chalybeate; and rain water should be used where no indifferent thermal springs existed.

Priestley was the first to imitate Selters water, by pouring diluted sulphuric acid over carbonate of lime, and thus setting free carbonic acid, with which the water was then impregnated*. Lane discovered that water thus rendered acidulous, had the power of keeping iron in solution. Magellhan further improved the method of impregnating water with carbonic acid. Corvinus and the Duke of Chaulnes, also applied themselves to this subject; but it was Tobern Bergmann, a Swede, who in the eighteenth century made the most important researches on this subject. He wished to drink mineral waters for violent haemorrhoidal colics, from which he had himself suffered for a long time, and for which he had found great relief at several German Spas; but as it was impossible to procure these waters in Sweden, during spring, when his sufferings greatly increased, he commenced making researches on the chemical composition of the springs, with the view of preparing artificial mineral waters. He analysed, by means of a greatly improved method, chiefly the waters of Seidschütz, Selters, Spa and Pyrmont. He combated the general belief in the existence in the natural waters of a hidden principle of great power, which could not be represented in artificial

* Directions for impregnating water with fixed air. London: 1772.

ones; and affirmed that, if their foreign ingredients were thoroughly well known, it would be easy enough to prepare exact imitations of them. Bergmann manufactured chiefly acidulous chalybeates and sulphurous waters; and effected a number of cures by them; but as he had only made qualitative, and not quantitative analyses of the Spas, his preparations were necessarily very imperfect. Other experiments of this kind were made by Leroi, Paul, Venel, and Duchanoy in France; Donald Monro and Adair in England; and Weber and Liphardt in Germany. It was, however, only in the first decennia of this century, that M. Struve, a German, succeeded in bringing the imitation of mineral waters to a high degree of perfection. He first made accurate analyses, qualitative as well as quantitative, of the springs and those strata of the earth through which they flowed, and afterwards composed artificial waters in strict accordance with the results thus obtained. Amongst others, he composed a Carlsbad water which Faraday declared to be identical with the natural one.

In our own time the therapeutical action of mineral waters has been studied chiefly by the medical Profession of Germany and France. Where so many excellent observers have applied themselves to this subject, it would be invidious to mention names: but there can be no doubt that, in this century, Hufeland and Lersch in Germany, and Durand-Fardel in France, have done most towards giving a scientific basis to a subject which is as difficult as it is important. —

Spas are only suitable for patients suffering from chronic diseases, and in these only if the composition of the blood has not become too much altered, and in the absence of considerable structural changes of important organs.

The therapeutical action of the Spas depends chiefly upon their chemical composition and temperature. Each mineral water which possesses curative powers is, by virtue of its peculiar composition and temperature, as it were, an individual remedy which, although it may greatly resemble others of the same class, is not absolutely identical with any other, either in a chemical or in a pharmacological point of view; for this reason it is especially suitable for certain diseases, in which other Spas, however similar to the former, are either less or not at all fit. It is therefore the duty of Physicians to make themselves thoroughly acquainted with the individual action of the several Spas, in order to be able to distinguish which one of them is most likely to prove successful in a given case.

Independently of the chemical composition and the temperature of mineral waters, there is a variety of other circumstances which have an important bearing upon the result of the treatment. Amongst these may be mentioned the situation of the place, its climate and neighbourhood, the formation of the soil, the character of the vegetation, the presence or absence of flowing and stagnant waters, barometric pressure, the mean annual temperature and the mean temperature of the summer months, the variations of temperature occurring

during the twenty-four hours, and from one month to the other, as well as the amount of moisture contained in the air. The pleasant neighbourhood and sublime scenery which surrounds many Spas, greatly aid the curative effects of the waters; while the gloomy and wild aspect of others, may at least in a certain number of cases, retard the benefit which would otherwise accrue from the peculiar virtues of the springs. The health of patients is also much influenced according as the Spa is in a low or Alpine neighbourhood, in broad and open places, or in narrow valleys surrounded by steep mountains. In places which are at a high elevation above the sea, the air is, by its greater purity and keenness, and also by its diminished density, an agent powerful for good, and it may be, for evil. Patients suffering from abdominal plethora, torpidity of the nervous system, atonic blennorrhoea of the respiratory organs, hysteria and hypochondriasis, are frequently much improved by being transferred to a high and airy mountainous health-resort; while such as suffer from an irritable condition of the lungs, with tendency to bronchitis and haemoptoë, are better in places at a lower level, with a mild and moist climate, and where there is sufficient protection against winds. Thus for instance, it is easy to understand why the acidulous chalybeates of St. Moritz, in the Upper Engadin, which is 5464 feet above the sea, and where the mean temperature of the summer months is 51°, should have different effects from those of Pyrmont, which is only 404 feet above the sea, and

where the mean annual temperature is 42°.5. The same may be said of the alkaline saline springs of Tarasp, in the Lower Engadin, which are at 4300 feet, and where the mean temperature of July is 51°.8, and of Marienbad in Bohemia, which is at 1932 feet and has a mean annual temperature of 45°.5; of the indifferent thermals of Gastein, at 2939 feet and with a mean summer temperature of 55°; of Pfäffers, at 2130 feet and with a mean summer temperature of 56°; of Wildbad, at 1323 feet and with a mean summer temperature of 61°; of Plombières, at 1272 feet; of Warmbrunn, at 1164 feet; of Schlangenbad, at 900 feet; of Teplitz, at 648 feet, and with a mean annual temperature of 50°.

The best time for commencing a mineral water cure is, in the majority of cases, the months of June, July and August. For patients who suffer from great irritability and rheumatic affections, May and September are, however, frequently more advisable. The quality of whey is best in May, while sea-baths prove most useful in the latter part of summer. Certain mineral waters, as for instance those of St. Moritz, can only be used in July and August, as before and after that time, the climate is too rough. The state of the weather in the several summer-months is also of importance; thus, in Gastein, May is very pleasant, June extremely changeable, July hot and stormy, while August and September are again pleasant. It may therefore happen that, if patients are sent to Gastein for the months of June and July, they derive little benefit from the waters, while they might have been greatly im-

proved or cured, had they been advised to resort to that Spa for August and September.

It was formerly believed that mineral waters should on no account be drunk during winter. As far as the physical and chemical properties of the springs are concerned, this opinion is, for the large majority of cases, untenable; and experience has shown that, even during severe winter, they may be employed with the utmost advantage. There are many diseases for which a mineral water cure proves more successful than any other treatment, and where it would be wrong to delay at all the use of the waters, as in the mean time the complaint would probably be aggravated, and the chances of a cure be thus lessened. In winter it is generally advisable to prescribe artificial or imported natural mineral waters; but if it should seem desirable to send patients to the Spas themselves, we must take care to choose such only as are protected against cutting North and East winds; where no sudden changes of temperature occur; where the mean winter temperature is comparatively high, and where all comforts, doubly necessary at that inclement season, are easily obtainable.

The mode of using mineral waters is now widely different from what it was in former times. The principle, that the benefit is more considerable, the more water is drunk, and that "crises" and "critical excretions" are necessary if the treatment is to be successful, is now rejected by all enlightened members of the medical Profession. Many cases have occurred in which

large quantities of water drunk in rapid succession, have not only greatly disturbed digestion, but have caused dropsy and general prostration; and a moderate use of the springs is, at the present day, justly believed to be the only safe plan.

The rules to be observed for the use of mineral waters, have also been greatly changed. We no longer advise "preparatory cures", "great cures", "little cures", "prophylactic cures" and "after-cures"; but the mode of treatment is made to suit the requirements of each individual case.

Waters which contain much carbonic acid and few salines, agree better with the stomach than such as are rich in solid constituents and poor in carbonic acid. These latter are however more easily borne, if they have a somewhat high temperature. If the water on issuing from the earth, is very hot, it is better to let it cool before taking it; water which is very cold, must, on the other hand, be warmed. If the quantity of carbonic acid contained in the water is very large, this should be allowed to stand for some time before drinking, or flatulency might be caused; and if the quantity of salines contained in a spring is very considerable, it is better to dilute it with some fresh-water. Moreover, in persons who have aweak and irritable stomach, milk or whey is frequently added, whereby the water is rendered more easily digestible.

In most cases, early rising during a mineral water cure is advisable. The water should be drunk before breakfast, at intervals of about one quarter of an hour

between each tumbler, moderate exercise being taken at the same time. It is on this account of great importance, that porticoes, covered walks, benches &c. should be in the immediate neighbourhood of the springs, so that exercise may be taken without fatigue, and regardless of the state of the weather. Persons who become exhausted by walking before breakfast, or who perspire freely in the morning, may take the water while in bed. Breakfast should not be taken immediately after the last tumbler has been emptied; but only half an hour or an hour afterwards. A second dose in the evening is frequently advisable.

In cases where it is not expedient to send patients to the Spas, much benefit may be obtained by prescribing mineral waters to be taken at home. Such was not the opinion of Hufeland who, when speaking of this subject, says:*— "Doubtless the use of mineral "waters immediately from the spring, that is, from the "living hand of Nature herself, is the only true meth-"od to obtain them in their whole integrity and power. "The slightest separation from the common mass; any "deviation from their usual temperature; the mere re-"moval from their subterranean laboratories to the con-"tact of air and light, must produce a very consider-"able decomposition of their more delicate ingredients; "so that we should in fact drink them with our lips "applied immediately to the spring itself, and when this

* Praktische Uebersicht der vorzüglichsten Heilquellen Deutschlands. Berlin 1820.

"is not possible, carry the cup to the mouth as quickly "as possible; for it is certain that every moment's "delay is accompanied with a loss of curative powers." Although there is much force in this argument, experience has shown that mineral waters may, when drunk at a distance from the place where they issue, exercise a most beneficial action upon certain diseases. No doubt the probability of a cure is greater, if the patient is able to travel to the Spa. In certain cases the journey, the change of air and of the mode of living, proves of great benefit; the mixture may be taken in its integrity, besides which baths of the most various kinds, douches, inhalations and other allied remedies, may be used with greater ease than is possible elsewhere. On the other hand, the patient who remains at home, has the advantage that the cure may be commenced at once, without loss of time, money, and trouble; he is not dependent upon the weather; and his medical attendants, familiar with his condition, may regulate the treatment as it proceeds.

If it has been decided that a patient is to drink mineral waters at home, we have then to choose between the imported natural, and the artificially-prepared waters. The former would be altogether preferable if it were possible to avoid their decomposition after being bottled; but this is unfortunately only too apt to occur if mineral waters have been kept for some time, however carefully the vessels in which they are placed, may have been closed. The waters more especially liable to decomposition, are the acidulous chalybeates and those

containing sulphates. The former, after being bottled, loose the carbonic acid which keeps iron in solution; bicarbonate of iron is then changed into carbonate, which is insoluble and precipitated at the bottom, whereby the mineral water becomes useless. In mineral waters containing sulphates, decomposition frequently takes place, if bits of organic matter, straw, cork &c. have been accidentally enclosed with the water. The sulphates are then decomposed, and sulphuretted hydrogen is formed. Waters containing sulphuretted hydrogen and sulphurets of metals, are also liable to be decomposed by the oxygen contained in the bottle previous to being filled. In order to avoid the injurious effects of oxygen upon the waters, and also to prevent the escape of carbonic acid, M. Hecht has introduced the method of filling the bottles with carbonic acid before the water is let in; but although this proceeding is very judicious, the escape of carbonic acid cannot be entirely prevented by it, and it is therefore not advisable to use natural imported chalybeates and sulphurous waters; while those containing sulphates and others may be useful, if sufficient care has been taken to prevent impurities from being mixed up with them.

Dr Constantin James * has lately stigmatised in strong terms the various *artificial mineral waters* which are employed as substitutes for the Spas themselves. He contends that these imitations are of no

* Gazette médicale de Paris. 1862. No. 6.

value whatever, save as mere refreshing table-drinks or purgatives; while, when ordered for baths, the most varied compositions are employed, and nothing analogous to the natural waters is obtained. No doubt most artificial mineral waters offered for sale richly deserve this censure; but the same cannot be said of Struve's imitations, which closely resemble the natural waters. In consequence of the great success of Struve's establishments, a large number of other manufacturers have invested their capital in the same trade, and most of these produce very inferior fabrications. The very cheapness of these imitations suggests the suspicion that they cannot have been carefully prepared. It is notorious that in some of these establishments, the bitter-water of Püllna is prepared by merely dissolving a certain amount of sulphate of soda in the water, and impregnating this latter with carbonic acid; Carlsbad water is in a similar manner made by dissolving sulphate of soda, chloride of sodium and carbonate of soda in water; and in many cases this is not even pure, but is used just as taken from wells or rivers! If therefore artificial mineral waters are prescribed, we should insist on Struve's imitations alone being used.

In many Spas, bathing is of even greater importance than drinking. The curative effects of baths are due both to the action of the water and its foreign ingredients upon the skin, and to the action of the gases ascending from the water, upon the mucous membrane of the air-passages. In most cases it is advisable

that bathing and drinking should not be commenced on the same day.

Baths are either taken in single rooms or in common reservoirs, the so-called "piscines" or swimming-baths, in which exercise is possible. In the majority of cases, the latter are far preferable to the former; but care should be taken that the piscines are spacious and well ventilated, and that the water is constantly renewed. Those of Wildbad, in Würtemberg, are patterns of their kind. The fear that contagious diseases may, in these piscines, be transferred by means of the water from one person to another, has by experience been shown to be altogether unfounded.

Baths are generally taken between breakfast and dinner, and no doubt this is, on the whole, a judicious proceeding. In many cases, however, especially if the weather is damp and cold, it is preferable to order them to be taken before going to bed, when perspiration is most effectually promoted, and the patient may also indulge the sleepiness generally induced by bathing. It is scarcely necessary to observe that baths should never be taken soon after hearty meals; and that great caution should be observed regarding their use by persons with a tendency to apoplexy.

"Psydracia thermalis", the "critical bath-eruption", the appearance of which was in former times welcomed alike by Physicians and patients, is now no longer looked upon as a favourable symptom, but rather as an unpleasant occurrence which it is by no means desirable to produce. Critical eruptions as such, are by

no means connected with an improvement in the condition of the patient, but are the necessary physiological consequence of a prolonged contact of water or mineral water with the skin.

The physiological and curative effects of baths are much enhanced by the addition of *graduated brines* and *mother-lye* to the water. Brines are graduated by letting the water slowly run down scaffoldings of thorns, which, in many watering-places, are from fifty to ninety feet high and several thousand feet long. In running over this immense surface, a considerable portion of the water evaporates, especially if the weather is warm and the wind high. The liquid thus becomes richer in salines, and if the process is repeated several times with the same water, this may at last assume a high degree of concentration. At the same time, minute particles of salines are, by the wind, carried into the surrounding atmosphere, and the inhalation of air thus impregnated, has in many instances proved useful to patients suffering from diseases of the respiratory organs.

When brines have been concentrated to such a degree that they contain from 140 to 180 grains of salines in sixteen ounces of water, they are, in many places, boiled, in order that those salines which are not easily soluble, such as chloride of sodium, silica, carbonate of lime, carbonate of magnesia, alumina, iron and manganese, may be precipitated and removed from the liquid. That which remains after several weeks' boiling, is called mother-lye. This is half salt, and half

water, as it contains from 2000 to 4000 grains of salines in the pound. Its chief solid constituents are chloride of calcium, magnesium and potassium, and bromide and iodide of sodium and magnesium. The Dead Sea is a huge natural mother-lye, formed by the long continued evaporation of water. This lake continually receives water, but has no visible outlet; and as it is situated at a very low level, viz. 1300 to 1340 feet below the Mediterranean, the water conveyed into it does not filter below-ground, but is removed chiefly by evaporation. Large quantities of salines are therefore precipitated, not only at the bottom, but also on its shores.

The chemical composition of the mother-lyes prepared at the several Spas, differs according to the composition of the waters from which they are formed, and the temperature at, and the length of time during, which they have been boiled. The most celebrated are those of Kreuznach, Halle, Volterra and Dürckheim. The quantity generally added to baths, varies from two to thirty quarts.

If mother-lye is again boiled, the liquid becomes even more concentrated, and after refrigeration crystallisation ensues. The hard substance which at last remains, is called *mother-lye-salt.* This contains a considerable quantity of water and is very hygroscopic, so that, if exposed to the air, it soon again assumes a liquid state. Great care is therefore necessary in exporting it. It is scarcely possible to preserve liquid mother-lye in barrels, as on account of its high spe-

cific gravity, it forces its way through the pores and joints of the wood. Mother-lye-salt is more easily exported, but if added to baths, it does not produce the same effects as if the liquid preparation is used; for as the different salines contained in it have different points of crystallisation, the layers at the top of the barrel are different from those at the bottom. If therefore one layer is used after the other, only parts, and not all the ingredients, of the mother-lye are employed. It would on this account appear advisable, either to again dissolve the whole contents of the barrel previous to using, or to export the liquid mother-lye in bottles covered with wicker-work, from which there would be no danger of its escaping.

The salts which are precipitated on boiling mineral waters, are used in many watering-places, and are also exported. Those most extensively employed are the Carlsbad, Epsom, and Krankenheil salts, and the Vichy, Bilin, and Gleichenberg pastilles. Such salts by no means constitute *in nuce* the mineral water, from which they are extracted; and if again dissolved in water, the solution only slightly resembles the Spa itself. It is easy to understand why this should be so, if we consider that by boiling not only do the gases escape altogether, but also protoxide of iron is changed into peroxide, sulphurets into sulphates, and bicarbonates into carbonates. Carlsbad-salt merely consists of sulphate of soda, carbonate of soda and chloride of sodium; and the proportion of sulphate of soda contained in this salt, is much more considerable than that con-

tained in the mineral water itself. Krankenheil-salt consists of carbonate and sesquicarbonate of soda, chloride of sodium, sulphate of soda, silicate of soda, sulphate of potash, iodide of sodium, bromide of sodium, and crenic acid. The pastilles of Vichy, Bilin and Gleichenberg, consist of carbonate of soda, sugar and gum. Such salts and pastilles may be used internally and externally. They are much employed for making cataplasms for engorged glands, eruptions of the skin &c. For this latter object, they are first dissolved in water, a piece of linen is then saturated with it and tied to the affected part, which proceeding is repeated as often as the linen becomes dry, so that the part acted upon is, as it were, in a continual vapour-bath. Moreover, it is possible that certain parts of the salines may, if the operation is continued for a certain length of time, be absorbed by the skin, and thus produce beneficial effects.

Medicated soaps are also prepared with the salts extracted from certain mineral waters. At Carlsbad, "Sprudel-Seife" is manufactured by adding oil to the mother-lye made of Sprudel-water. At Krankenheil, so-called iodine-soda, and iodine-soda-sulphur-soaps, are prepared and successfully used in chronic diseases of the skin. One or two pieces of such soaps are added to a bath, or the suffering parts are well lathered and rubbed with it.—

Spray-baths of mineral waters have lately been introduced into practice by Messrs Sales-Girons and Mathieu. M. Girons who recommends such baths chiefly

for diseases of the respiratory organs ("Thérapeutique respiratoire"), started from the idea that, since the inhalation of the natural vapours rising from the springs had been shown to be very beneficial in certain diseases of the air-passages, even more striking effects might be obtained by reducing the mineral water itself to spray or mist, and applying it locally to the mucous membrane of the larynx, the trachea and the lungs. At first he set apart a chamber in which the patients could inspire the spray; and afterwards constructed a portable apparatus, by means of which spray-baths may be taken in the patient's own room.

The proceeding just mentioned has been subjected to severe criticism on the part of Messrs Réné-Briau, Pietra Santa, and Champouillon. M. Pietra Santa, of Eaux Bonnes, asserts that the spray produced by M. Girons' apparatus, does not contain the essential constituents of the mineral waters. Sulphuretted hydrogen and sulphate of soda, which are amongst the most important constituents of the waters of Eaux Bonnes, could not be discovered in the spray; besides which its temperature had fallen from 86° to 64°. On examining the urine of persons who had inhaled the mist, no trace of sulphur could, by the addition of nitrate of silver, be discovered in the urine, which may always be done when sulphurous waters have been internally administered. M. Pietra Santa denies that mineral-water-spray can arrive in the bronchial tubes, nor did he find any benefit result to two patients suffering from chronic laryngitis who inhaled the spray for

twelve days. M. Réné-Briau asserts that, even if the apparatus were so constructed as to disseminate the mineral ingredients of the water, this could never penetrate into the air-passages, their structure being such as to preclude contact with anything but the atmosphere, or an analogous mixture of gases. Even steam is, according to the same observer, only tolerated when greatly diluted with air. Every liquid, on first entering the larynx, causes cough by reflex action, as shown by the therapeutical experiments of Bretonneau, Trousseau and Barthez; and on causing patients to inhale spray, according to M. Girons' directions, no cough was produced. In forty-seven patients treated by M. Briau at Eaux Bonnes, this Physician satisfied himself, that the pulverised mineral water was immediately condensed in the mouth, nostrils and pharynx, and ran in a fine stream down the chin. Besides it appeared that only a tenth part of the water used for these experiments, really became pulverised, and that even the largest portion of this was carried to neighbouring parts, and did not arrive in the mouth. Experiments made with a pulverised solution of perchloride of iron on dogs and horses, also showed that nothing of this substance penetrated into the bronchial tubes of the animals. M. Champouillon caused a patient who suffered from bronchitis, to inhale the spray of a similar solution, but could not discover any traces of it in the expectoration afterwards discharged by that patient. While M. Girons' propositions have thus been strongly assailed, there are, on the other hand,

the experiments of Henry, Demarquay and Poggiale, which are strongly in favour of the same. M. Henry contends, that he has found all the really important elements of the mineral waters in the spray produced by M. Girons' apparatus, and that he discovered iron in the bronchi of a pig, which he had caused to inhale ferruginous spray for half an hour. M. Demarquay's experiments on rabbits, dogs and patients, seem indeed to leave little doubt that mineral-water-spray may really enter the respiratory organs. Amongst others, he operated upon a patient who had a permanent tracheal fistula; she was made to inhale a pulverised solution of tannine by the mouth, and by applying the appropriate tests to the fistulous opening, the presence in the trachea of the substance mentioned was discovered. Almost all of those animals which were not killed after having inspired a solution of perchloride of iron, died of violent broncho-pneumonia within twenty-four hours after that operation. M. Poggiale confirms that, if sulphurous thermal waters are transformed into spray, they lose by far the largest proportion of the sulphur they contain, and that their temperature is moreover considerably lowered. M. Durand-Fardel* considers that pulverised liquids penetrate largely into the region above the glottis, and that they also reach the larynx and the trachea, but not the bronchial tubes. The inhalation of mineral water spray can therefore only be useful in affections of the mouth and pharynx,

* Gazette hebdomadaire &c. May 1862, p. 285.

and perhaps in those of the larynx and trachea, but not in diseases of the lungs.

M. Mathieu has recommended the use of general spray-baths of mineral waters, instead of ordinary mineral water baths. Proceeding from the idea that in a common bath that portion only of the liquid is of use to the patient, which is in immediate contact with the skin, and which is only slowly and imperfectly renewed, he constructed an apparatus by means of which the quantity of fluid can be greatly economised, while at the same time fresh layers of liquid may continually be brought to bear upon the surface of the body. By means of M. Mathieu's apparatus, the patient may, with the expenditure of only five to seven pints of liquid, remain in a spray-bath for a whole hour, and costly medicated liquids may thus be administered at a trifling expense. M. Hardy who has used such spray-baths in his clinique, in the Hôpital St. Louis, has found the effects produced by them very similar to those of ordinary water baths; while M. Gavarret, in his report to the French Academy, speaks highly of the invention, which he recommends for the treatment of scrofula and diseases of the skin. In affections of the scalp and the face, spray-baths are more especially useful, because their action is so mild that the patient may expose the head to the spray for a considerable time without inconvenience. Baths of the natural Carlsbad, Vichy, Ems, Wiesbaden, and other waters, may therefore now, by means of this apparatus, be given in hospitals and in the patient's own room, at a moderate

cost. However ingenious M. Mathieu's invention, it is well to state that the "idea" upon which it is based, viz. that that portion of the water alone is of use to the patient which touches the skin, is altogether incorrect; for thick layers of water have an action widely different from that of thin layers, not only as regards conduction, but also radiation, evaporation, and a variety of other influences.—

The douche, or affusion of a jet of water to different parts of the body, is, when properly administered, an excellent auxiliary to a mineral water cure. The action of the douche depends chiefly upon the quantity of water which is poured down upon the patient, the force of the stream, and the length of time during which it is applied. The so-called Scotch douche, which consists of an alternation of hot and cold water, seems in many cases preferable to the warm douche. The sensation produced by a proper application of the douche is, to most persons, exceedingly pleasant. After it has been applied for a time varying from five to fifteen minutes, the patient should be dried with a Turkish towel, then wrapped up in flannel and blankets, and remain in bed for an hour, in order that perspiration may not be interrupted. The doucheurs and doucheuses of Aix-la-Chapelle, Aix in Savoy, and Wiesbaden have the best, and those of Balaruc, in France, the worst reputation for dexterity.

The uterus-douche employed at Ems deserves special mention. The water used for this purpose is that of the Bubenquelle, which furnishes about 975 cubic

feet of water in twenty-four hours, and which spouts forth from a basin in a jet five lines thick and three inches high. The patient is seated on a perforated stool, and the jet is allowed to penetrate into the vagina. The water has a temperature of 89°. The force of the jet, and the chemical action and temperature of the water, have in many cases of hypertrophy and induration of the uterus proved curative; menstruation has been re-established and conception rendered possible.

Carbonic acid baths are given at many watering places. The bath is either local or general. If the latter is prescribed, the patient sits in a tub, the anterior part of which may be opened and closed at libitum, in order to allow going in and out. The tub contains a moveable seat and a contrivance by which the neck is surrounded with a somewhat tight collar in order to prevent the escape of the gas, the head being left free. This tub is furnished with a double bottom and two pipes, one of which admits aqueous vapours, and the other carbonic acid. The former of these pipes opens between the two bottoms, and the latter about two feet above the upper bottom. It is therefore possible, by means of this apparatus, to give either vapour or carbonic acid baths, or both at the same time. In the majority of cases it is advisable to let vapours in the tub first, so that the skin of the patient may be moistened and thus become more sensitive to the subsequent application of carbonic acid. Carbonic acid may also, by means of special contrivances, be made to act upon certain parts locally, such as the generative organs &c.

It is also inhaled in inhalation rooms; as for instance, in Franzensbad, where such a room has been built over the far-famed Polterbrunnen, from which powerful exhalations of this gas continually take place. Rooms for the inhalation of the natural vapours ascending from the springs (especially of nitrogen), and of the vapours developed in preparing brines, are also set apart in many watering places, for diseases of the respiratory organs.

Finally, a few words on mineral mud and moor, whey, "grape-cures" and "pine-leaf-cures", which are much employed simultaneously with, or after, mineral water cures. The mud of the Nile was recommended by Galenus for therapeutical purposes. The moors chiefly employed at the present time, are those of Franzensbad, Marienbad, Pyrmont, Meinberg, Abano, Montmorency, and Valdieri. Mineral mud is, in most cases, a product of the decomposition of plants under the influence of meteoric or mineral water. In a few places, however, it issues, as it were, ready-made from the ground. Mineral moor is formed wherever mineral water flows through moor-land. The minerals contained in the water act upon the organic substances of the moor, whereby many new compounds are formed. Thus sulphates are changed into sulphurets; vegetable acids into carbonic acid; phosphoric acid combines with iron, lime and other earthy substances; peroxide of iron is changed into protoxide, and sulphuretted and carburetted hydrogen and ammonia are evolved. According to the prevalence of certain

ingredients in the moor, sulphuretted, carburetted, tablesalt, earthy and gelatinous mineral moor are distinguished; but such a classification is of very little practical importance. It is almost certain that none of their ingredients are absorbed, with the exception only of carbonic acid, sulphuretted hydrogen, and formic acid. The action of mud and moor is chiefly mechanical. They have a higher specific gravity than water, and the skin becomes considerably congested under their influence; besides perspiration and radiation are in a great measure prevented, as the humus and alumina which are contained in these substances, cover the skin as it were with an impermeable layer. Mud and moor also possess a less considerable capacity of heat than water, so that it is possible, by means of them, to apply a more considerable degree of warmth than by water-baths. Their action is also different according to their temperature and the length of time they are applied. If the temperature of the bath is low, the pulse is retarded; if it is high, the pulse is accelerated, and vertigo, sickness, ringing in the ears, and other unpleasant symptoms may be caused by it. Mud and moor-baths, both local and general, are useful in all cases in which warm water baths and cataplasms are advisable. They are chiefly employed in diseases of the skin, suppressed perspiration, inveterate gout, and rheumatic contractions.

Whey is milk from which caseïne and butter have been removed. It is prepared by adding acetic acid or runnet to milk. Four to six drops of good runnet

are sufficient to transform twenty-four quarts of milk into whey. This is a nearly transparent liquid, of a yellow-greenish colour, an aromatic odour, and a sweetish taste. Its chief ingredients are sugar of milk (from 380 to 500 grains in the pound), chloride of potassium (from 13 to 15 grains), carbonate of soda (3 to 4 grains) and chloride of sodium (2 to 3 grains); besides which it contains small quantities of iodine and fluorine. For preparing whey, goat's milk is generally preferred; but the milk of cows, asses and sheep, is also very suitable for this purpose. The most renowned whey-cures are those of Appenzell, Gais, Heiden, Kreuth, Meran, and Ischl.

Whey is used for drinking as well as for bathing. Whey-baths have been found to reduce the frequency of the pulse; and are used in anaemia, scrofula, gout, and general debility of infants. It is drunk either pure or mixed with water. For most persons it is easily digestible, promotes the appetite, and has a gentle action upon the bowels. Large quantities cause loss of appetite, diarrhoea, and great aversion to the drink. In some persons however even small doses produce sickness, constipation, and even icterus. Whey is no specific remedy for any one disease, but is useful for improving the nutrition, and gently stirring up the abdominal secretions. Thus it may be prescribed for persons suffering from scrofula, gout, haemorrhoids, intestinal atony, and irritability of the nervous system; but it may be dangerous where there is a tendency to congestion and haemoptysis.

A methodical use of *grapes* is not unfrequently prescribed after a mineral water. Grapes contain more nitrogenous matter, vegetable acids and lime than whey; and no milk-sugar, but grape-sugar. Otherwise the juice of grapes and whey resemble each other in their chemical composition. The mineral constituents of the juice of grapes are analogous to those contained in the Spas of Fachingen, Geilnau, and others; but the former contains a rather considerable amount of phosphoric acid and potassium, which in mineral waters are only found in minute quantities.

The best time for "grape-cures" is the latter part of September. The quantity to be taken varies from one pound and a half to six pounds per diem. Grapes agree very well with most persons; sometimes, however, palpitations of the heart, epistaxis, haemoptysis and other symptoms have been observed after a methodic use of them. They generally render the faeces darker and more fluid, and augment the quantity of secretions. Grapes are useful in abdominal plethora, scrofula, tuberculosis, gravel and certain diseases of the nervous system.

Pine-leaf-cures are an invention of more modern date. Preparations of the leaves of *Pinus Abies*, *Larix Europaea* &c., are, in Spas and special pine-leaf-establishments, used both externally and internally, in connexion with, or after, a mineral water cure. Pine-leaf-water-, vapour-, and mud-baths, douches and inhalations are in these establishments used externally; by these means irritation and hyperaemia of the capillary ves-

sels of the parts acted upon is produced; and diseases consequent upon an atonic condition of the skin, cellular tissue, and the mucous membranes, may be benefitted thereby. At the same time the freshly-expressed juice of the pine, and infusions and decoctions of pine-leaves, the chief ingredient of which is an essential oil, are internally administered. By this medication diuresis is increased, the pulse accelerated, and the nervous system gently stirred up. Menstruation frequently ensues earlier under the influence of the treatment, and obstinate cases of chlorosis, gout, rheumatism, scrofula, &c. are beneficially affected.

It is impossible to determine beforehand, how long a mineral water cure should last in a given case. This entirely depends upon the symptoms observed in the course of the treatment, and should therefore be left to the judgment of the Physician of the Spa. Experience shows, however, that in most cases the treatment should not be protracted beyond the space of six weeks or two months. If the patients, after having used the water for some time, feel a decided aversion to the same, it should be discontinued at once.

In children, pregnant women, and old persons, mineral waters must be used with special caution. It was formerly believed that pregnancy precluded the use of Spas; but so far from this being the case, they often have a most beneficial effect, if employed during this term, not only upon the mother but also upon the foetus. Dr Brück, of Driburg, has lately recorded a case, in which the use of the carbonic acid baths of that place checked

a tendency which existed in a lady, to give birth to monsters. Her general health was very good, but her first infant was a microcephalus. Having again become pregnant, she was advised to resort to the baths of Driburg, which she did and afterwards gave birth to a healthy and well-formed child. In the third pregnancy she neglected the baths, and was again delivered of a microcephalus. When pregnant for the fourth time, she returned to the baths, which had the same beneficial effect as before. On the fifth such occasion, she did not think it necessary to submit again to that treatment which had twice proved so eminently successful; and the consequence was that her misfortune recurred. Since then she has regularly visited Driburg, and her further confinements have been perfectly satisfactory.

Indulgence in the pleasures of the table, gambling, and excesses of every description, frequently counteract the beneficial effects of a mineral water cure. Physicians should therefore impress upon their patients the danger of such and similar follies.

Freedom from business and care is likewise an important auxiliary to the treatment. Patients who resort to Spas, should keep in mind the lines inscribed on the thermal baths of Antoninus, in Rome:

> Curae vacuus hunc adeas locum,
> Ut morborum vacuus abire queas;
> Non enim hic curatur qui curat.*

* Devoid of care approach this spot,
That you may part devoid of sickness;
There is no cure for those who care.

I. ALKALINE ACIDULOUS SPRINGS.

The most important Spas of this class are the thermals of Vichy, and the cold springs of Fachingen, Geilnau and Bilin. Their therapeutical effects are chiefly due to the water, its temperature, and the carbonic acid and bicarbonate of soda, which form their essential ingredients.

At Vichy nine springs are used for drinking and bathing, viz. the Puits Carré (110°.5), Puits Chomel (107°.6), Grande Grille (105°.8), Source de l'Hôpital (89°), Source Lucas (83°.3), Source du Parc (71°.6), Source des Dames (62°.6), Source d'Hauterive (59°), and Source des Célestins (53°.6). According to M. Bouquet's analysis which I have reduced from 1000 grammes to sixteen ounces, the chemical composition of the most important of them is as follows:—

1. *Solids.*

	Grande Grille.	Puits Chomel.
Bicarbonate of soda	37.50 grains	39.09 grains
bicarbonate of potash . . .	2.70 „	2.84 „
bicarbonate of magnesia . .	2.32 „	2.59 „
bicarbonate of strontia . .	0.02 „	0.02 „
bicarbonate of lime	3.33 „	3.27 „
bicarbonate of iron	0.03 „	0.03 „
bicarbonate of manganese .	traces	traces
sulphate of soda	2.29 „	2.29 „
phosphate of soda	0.78 „	0.53 „

	Grande Grille.	Puits Chomel.
arseniate of soda	0.01 grains	0.01 grains
borate of soda	traces	traces
chloride of sodium	4.10 „	4.10 „
silica	0.05 „	0.05 „
	54.13 grains	54.82 grains

2. *Gases.*

Carbonic acid	6.97 grains.	5.91 grains.

1. *Solids.*

	Fontaine de l'hôpital.	Fontaine des Célestins.
Bicarbonate of soda	38.60 grains	39.19 grains
bicarbonate of potash . . .	3.37 „	2.41 „
bicarbonate of magnesia . .	1.53 „	2.51 „
bicarbonate of strontia . .	0.03 „	0.03 „
bicarbonate of lime	4.37 „	3.54 „
bicarbonate of iron	0.03 „	0.03 „
bicarbonate of manganese .	traces	traces
sulphate of soda	2.29 „	2.29 „
phosphate of soda	0.35 „	0.76 „
arseniate of soda	0.01 „	0.01 „
borate of soda	traces	traces
chloride of sodium	3.97 „	4.10 „
silica	0.03 „	0.04 „
	53.58 grains	54.91 grains

2. *Gases.*

free carbonic acid	8.21 grains.	8.04 grains.

1. *Solids.*

	Grand Puits Carré.	Puits d'Hauterive.
Bicarbonate of soda . .	37.57 grains	36.99 grains
bicarbonate of potash .	2.90 „	1.45 „
bicarbonate of magnesia	2.56 „	3.84 „
bicarbonate of strontia	0.02 „	0.05 „
bicarbonate of lime . .	3.22 „	3.31 „
bicarbonate of iron . .	0.03 „	0.07 „
bicarbonate of manganese	traces	traces
sulphate of soda . . .	2.29 „	2.29 „
phosphate of soda . .	0.21 „	0.35 „
arseniate of soda . . .	0.01 „	0.01 „
borate of soda	traces	traces
chloride of sodium . .	4.10 „	4.10 „
silica	0.05 „	0.05 „
	52.96 grains.	52.53 grains.

2. *Gases.*

carbonic acid.	6.71 grains.	20.92 grains.

Amongst the ingredients of minor importance, the bicarbonates of potash and magnesia, and the arseniate of soda, are valuable in a therapeutical point of view. All these springs contain, moreover, a variable quantity of barègine.

The following is the analysis, by Redtenbacher, of the Josephsquelle of Bilin, which has a temperature of 53°.4.

1. *Solids.*

Carbonate of soda . . .	23.106	grains
carbonate of lime . . .	3.089	„
carbonate of magnesia .	1.098	„
carbonate of lithia . . .	0.110	„
carbonate of protoxide of iron	0.080	„
sulphate of soda . . .	6.350	„
sulphate of potash . .	0.985	„
chloride of sodium . .	2.935	„
phosphate of alumina .	0.065	„
silica	0.244	„
	38.062	grains.

2. *Gases.*

free carbonic acid	15.092	cubic inches
carbonic acid bound to bicarbonates	17.247	„ „
	32.339	cubic inches.

The sulphate of soda, protoxide of iron and carbonate of lithia are valuable accessories to the carbonic acid and carbonate of soda contained in the Bilin water.

The chemical composition of the principal spring of Fachingen (50°), is according to Fresenius, as follows: —

1. *Solids.*

Bicarbonate of soda	28.0883	grains.
bicarbonate of lime	2.8960	„
bicarbonate of magnesia	2.2912	„
bicarbonate of protoxide of iron.	0.1103	„
bicarbonate of strontia	0.0008	„
bicarbonate of lithia	0.0006	„

sulphate of soda	0.1372	grains
phosphate of soda	0.0506	„
phosphate of lithia	0.0002	„
phosphate of lime	0.0004	„
phosphate of alumina	0.0003	„
phosphate of silica	0.2610	„
fluoride of calcium	0.0027	„
chloride of sodium	4.5574	„
chloride of calcium	0.0034	„
	38.3918	grains.

2. *Gases.*

carbonic acid	32.9750	cubic inches
nitrogen	0.0256	„ „
	33.0006	cubic inches.

The protoxide of iron is a valuable ingredient of this spring, while the quantity of the sulphate of soda, and of the bicarbonate and phosphate of lithia, is so small that we are not justified in ascribing to them any particular power.

The springs of Geilnau (50°) contain, according to Fresenius, the following foreign substances: —

1. *Solids.*

Bicarbonate of soda	8.142	grains
bicarbonate of lime	3.767	„
bicarbonate of magnesia	2.788	„
bicarbonate of baryta	0.001	„
bicarbonate of iron	0.294	„
bicarbonate of manganese	0.035	„

sulphate of potash	0.135	grains
sulphate of soda	0.066	„
phosphate of soda	0.003	„
chloride of sodium	0.278	„
	16.699	grains.

2. *Gases.*

Bicarbonate of ammonia . .	0.010	grains
free carbonic acid	21.400	„
nitrogen	0.119	„
	21.529	grains.

and traces of carbonate of lithia, borate of soda, alumina, nitrate of soda, fluoride of calcium, carbonate of strontia, organic matter, and sulphuretted hydrogen. Bicarbonate of protoxide of iron is the chief accessory ingredient of the Geilnau waters.

Acidulous alkaline springs are useful in certain forms of *indigestion.* In patients who complain of aversion to food, pappy taste, nausea, retching, vomiting, flatulence, pain and pressure in the epigastrium, heartburn, depression after meals, constipation alternating with diarrhoea &c., a judicious administration of the alkaline acidulous waters often proves curative, provided that the symptoms mentioned merely arise from deficient innervation and secretion of the gastric juice, or from chronic catarrh of, and excessive acidity in, the stomach. Carbonic acid improves the innervation and secretion, while by the bicarbonate of soda the surplus acid is neutralised, and the tenacious mucus which in cases of chronic catarrh adheres to the walls

of the stomach, is fluidified. But if the indigestion is due to structural diseases of the stomach, such as erosions, ulcer &c., or if it arises from an active catarrhalic inflammation of that organ, the affection would, by this medication, very probably be aggravated.

Patients suffering from those forms of indigestion which are suitable for alkaline acidulous Spas, may be sent to Vichy, there to use the Grande Grille, which is easily borne even by a weak stomach. The treatment should be commenced with small doses, to be taken in the morning before breakfast. At first two glasses, containing about four ounces each, are sufficient; and the dose may then be gradually increased to four and six tumblersful. In some cases it is also advisable to prescribe a few glasses to be taken in the evening. Strict diet is indispensable during a course of Vichy water. Beaf-tea, veal and poultry suit the stomach best; and the patients must abstain from brandy, milk, and heavy amylaceous food. If constipation should ensue, enemata with the mineral water are preferable to purgatives. Baths of Vichy water also prove beneficial in the class of cases under consideration. The "thermal Establishment" of Vichy contains seventy-two bath-rooms and four douches; but such is the crowd of patients resorting to them, that bathing generally begins at 3 o'clock a. m. The pure thermal water being too exciting for this purpose, it is only used after having been mixed with river-water.

If patients cannot go to Vichy, they may drink this water at home, or they may take the waters of Bilin,

Geilnau and Fachingen, all of which are exported in large quantities, and, when carefully bottled, are not at all, or only slightly, decomposed. Of Fachingen water alone, more than 500,000 bottles are annually exported. Patients who undergo a mineral water cure at Carlsbad, may, if suffering from indigestion and acidity in the stomach, take with great benefit the acidulous alkaline water of the neighbouring Giesshübel, or Buch-Säuerling, which, according to Göttel, contains in sixteen ounces:—

1. *Solids.*

Carbonate of soda . . . . , .	7.096	grains
carbonate of lime	1.459	„
carbonate of magnesia . . .	0.340	„
carbonate of protoxide of iron	0.0004	„
carbonate of potash	0.656	„
sulphate of potash	0.226	„
chloride of potassium	0.376	„
silica	0.656	„
alumina	0.017	„
	10.972	grains.

2. *Gases.*

Carbonic acid	38.208	cubic inches.

This is one of the few mineral waters which does not contain any chloride of sodium, and which owes its action exclusively to the water, the carbonic acid, and the bicarbonate of soda. As its temperature is rather low (48°.6), it is more easily borne if warmed,

or mixed with milk or whey. 150,000 bottles of this water are annually exported.

Patients who, for scrofula and allied diseases, use the brine-springs of Nauheim, in Hesse, may, if they also suffer from those forms of indigestion for which acidulous alkalines are applicable, take with advantage the water of the acidulous alkaline spring of that place, which has a very mild action. According to Bromeis, it contains in sixteen ounces:—

1. *Solids.*

Bicarbonate of soda	3.763	grains
bicarbonate of lime	2.506	„
bicarbonate of protoxide of iron . .	0.076	„
bicarbonate of protoxide of manganese	traces	
chloride of sodium	0.556	„
chloride of potassium	traces	
chloride of calcium	0.161	„
chloride of magnesium	0.798	„
bromide of magnesium	traces	
sulphate of lime	0.103	„
silica	0.069	„
	8.032	grains.

2. *Gases.*

Carbonic acid	6.776	„
nitrogen	0.038	„
	6.814	grains.

The Victoriaquelle, of Neuenahr, is also serviceable in this class of cases. It contains in sixteen ounces:—

1. *Solids.*

Bicarbonate of soda	10.80	grains
bicarbonate of magnesia . .	3.74	„
bicarbonate of lime	3.30	„
sulphate of soda	0.73	„
chloride of sodium	0.91	„
protoxide of iron and alumina	0.10	„
silica	0.25	„
	19.83	grains.

2. *Gases.*

Carbonic acid	12.86	„

The Apollinarisbrunnen and Mariensprudel, near the same place, possess, according to Bisch and Mohr, the following ingredients:—

1. *Solids.*

	Apollinarisbrunnen (according to Bisch) 1852 70°.25.	Mariensprudel (according to Mohr) 1860 101°.75.
Carbonate of soda . .	9.65 grains	5.62 grains
carbonate of magnesia	3.39 „	2.68 „
carbonate of lime . .	0.45 „	1.61 „
chloride of sodium .	3.57 „	0.69 „
sulphate of soda . . .	2.30 „	0.76 „
carbonate of protoxide of iron	0.15 „	0.06 „
silica	0.06 „	0.19 „
	19.59 grains.	11.66 grains.

2. *Gases.*

Carbonic acid . . .	47.04 cubic inches.	22.52 cub. inch.

The springs of Preblau, in Carniola, which contain 21 grains of carbonate of soda and 66 cubic inches of carbonic acid; and those of Fellathal, in Illyria, in which 24.9 grains of carbonate of soda, and 38 cubic inches of carbonic acid are found, are much used for indigestion by the inhabitants of the neighbourhood. I will however add that, if the affection is of long standing and the patients are much exhausted and emaciated, saline chalybeates are preferable to acidulous alkalines.

In *icterus* arising from catarrh of the hepatic ducts, and *gall-stones*, the alkaline acidulous springs often prove curative, especially when there is neither disposition to congestions and haemorrhage, nor great irritability of the nervous system. In cases of the latter kind, the carbonic acid of these Spas is sometimes too exciting in its action. Baths of the same waters are very effectual in relieving the pain which accompanies the presence of stones in the gall-bladder. After a week or fortnight's use of these Spas, both externally and internally, gall-stones are frequently discharged, and the right hypochondrium then becomes soft, and free from pain. In cases of this kind, the diet must be carefully regulated, and in order to prevent a recurrence of the disease, a methodical use of the Vichy or Fachingen water should be continued for some months after the calculi have been discharged. In certain forms of this affection, however, the waters of Kissingen, Carlsbad and Marienbad, are even more efficacious than the acidulous alkalines.

In *gout* the Vichy and other waters of this group, have for a long time been extensively used; but it cannot be said that they have altogether answered the expectations which had been formed of them in this regard. According to Dr James, the Vichy waters should only be employed in cases of tonic gout, where there are regular paroxysms of the disease, with inflammation of the joints, and violent febrile symptoms; while in atonic gout, where the paroxysms are less marked and more frequent, and where the patients suffer from oedema of the feet and have a cachectic complexion, they ought not to be prescribed. For my part I have much faith in Vichy waters for gout, if the dyspeptic symptoms are very prominent; the internal use of the water should then always be combined with that of the baths. Fachingen and Geilnau are preferable to the Vichy waters, if the patients are very weak and irritable. In most forms of gout, however, the alkaline saline waters of Carlsbad and Marienbad, the muriated thermals of Wiesbaden, and the lithia waters of Baden-Baden, give better promise of a cure than the acidulous alkalines.

Uric acid diathesis is frequently checked by the Vichy waters, which produce a considerable alteration in the assimilation and the general metamorphosis of matter. Dr Villemin has found that, after a week's use of these waters, the urine of patients suffering from uric acid diathesis, contained large quantities of urate of soda, instead of uric acid, and that this salt in some

cases continued to be discharged till the end of the cure.

The acidulous alkaline springs produce very beneficial results in cases of *renal calculi and gravel*, especially if the patients are not too much exhausted by suffering. Acting as diuretics, they greatly facilitate the elimination of these formations. Baths of the same waters relieve the pain and the spasmodic contractions of the uretheres and the bladder, and thereby also promote the discharge of gravel. The temperature of the baths should in such cases be 90° to 93°, and the patients should remain in them from one to two hours. Renal calculi are often discharged while the patient is in the bath. In cases of this description, the waters of Bilin, Fachingen and Geilnau are not so energetical in their effects as the Vichy waters; they are however appropriate in the milder forms of the disease, and it is frequently advisable that their use should be succeeded by a grape-cure.

The acidulous alkaline Spas have been much praised as solvents of *stone in the bladder;* but their reputation as such is totally unjustified. They are efficacious in certain cases of catarrh of the bladder, especially if this is dependent upon an enlargement of the prostate gland, or stricture of the urethra. While these latter diseases continue, the waters can, of course, only relieve some of the unpleasant symptoms attending them; but if the causes of the catarrh of the bladder have been removed, and the discharge and other symptoms still continue, the waters may prove curative.

They are also exceedingly beneficial in that form of catarrh which is observed in old persons in consequence of atony of the bladder. In such cases they may serve as real preventives of calculus in the bladder, as they do not allow an accumulation of mucus in that organ, which might become the nucleus of stone.

In chronic *catarrh of the respiratory organs* the alkaline acidulous Spas have been much employed; they are suitable after the inflammation has subsided, when the affection has become chronic, and a tough and tenacious mucus is with difficulty expectorated. In the same manner they may be prescribed in certain cases of emphysema, if tenacious secretion is to be fluidified; but as they always produce congestion of the mucous membrane of the lungs, their use is not allowed where there is tendency to haemoptoe, and if emphysema is connected with heart disease. In the majority of cases moreover, the Spas of this class are far inferior to the muriated acidulous alkalines. In catarrh of the mucous membrane of the uterus and the vagina, hip-baths with alkaline waters are useful, and in obstinate catarrh of the eyes and ears the local application of carbonic acid gas may effect a cure.

For *abdominal plethora*, congestion of the liver and spleen, brought on by want of exercise, habitual constipation and the use of highly-seasoned food, the Spas of this class are much employed, although the alkaline salines are in most cases preferable. The Vichy waters often act beneficially on such patients by causing haemorrhoidal bleedings, after which the most unpleasant

symptoms of portal plethora frequently disappear. In cases of this kind, especially if the patients are of sluggish habits and constitution, large doses of the water, such as eight or ten tumblersful per diem, may be necessary; while baths are generally not advisable.

If *diabetes* is connected with gout and disordered liver, the Vichy waters have often a beneficial action upon this formidable disease, although it is scarcely to be assumed that they should ever prove curative. Experience shows that in cases of the kind mentioned, the amount of sugar in the urine decreases after the first week's use of the waters; at the same time the thirst is diminished, the appetite improved, the skin becomes moister, the muscles firmer, and the mind more cheerful. In some instances, diabetes has, by the use of the Vichy waters, been brought to a standstill for years.

II. MURIATED ALKALINE ACIDULOUS SPRINGS.

The most prominent Spas of this class are Ems, Selters, Luhatschowitz and Salzbrunn.

At Ems, a considerable number of mineral springs issue; those most frequently employed being the Kesselbrunnen and the Krähnchen. These have, according to Fresenius, the following composition:—

1. *Solids.*

	Krähnchen. 85°.1.		Kesselbrunnen. 115°.	
Bicarbonate of soda . .	14.8376	grains	15.1974	grains
chloride of sodium . .	7.0841	„	7.7705	„
sulphate of soda	0.1377	„	0.0061	„
sulphate of potash . . .	0.3286	„	0.3937	„
bicarbonate of lime . .	1.7246	„	1.8129	„
bicarbonate of magnesia	1.5051	„	1.4360	„
bicarbonate of protoxide of iron	0.0166	„	0.0278	„
bicarbonate of manganese	0.0072	„	0.0047	„
bicarbonate of baryta / bicarbonate of strontia	0.0011	„	0.0036	„
phosphate of alumina .	0.0032	„	0.0096	„
silica	0.3797	„	0.3648	„
	26.0259	grains	27.0272	grains

2. *Gases.*

Free carbonic acid . .	8.3249	c. inch.	6.7886	c. i.

The analysis of the "Fürstenbrunnen" and the "Neue Quelle" by the same chemist has given the following results:—

1. *Solids.*

	Fürstenbrunnen. 95°.4.		Neue Quelle. 117°.5.	
Bicarbonate of soda . .	15.6031	grains	15.93	grains
chloride of sodium . .	7.5509	„	7.27	„
sulphate of soda	0.1550	„	0.10	„
sulphate of potash . . .	0.3014	„	0.43	„

	Fürstenbrunnen. 95°.4.	Neue Quelle. 117°.5.
bicarbonate of lime . .	1.7760 grains	1.78 grains
bicarbonate of magnesia	1.5357 „	1.54 „
bicarbonate of protoxide of iron	0.0203 „	0.03 „
bicarbonate of manganese	0.0060 „	0.01 „
bicarbonate of strontia / bicarbonate of baryta	0.0021 „	0.002 „
phosphate of alumina .	0.0033 „	0.009 „
silica.	0.3777 „	0.37 „
	27.3322 grains.	27.67 grains.

2. *Gases.*

Carbonic acid	6.9275 c. inch.	6.52 c. inch.

The composition of the far-famed muriated alkaline acidulous spring of Selters, in Nassau, is, according to Kastner, the following:—

1. *Solids.*

Bicarbonate of soda . . .	9.7741 grains
chloride of sodium . . .	17.2285 „
chloride of potassium . .	0.2890 „
sulphate of soda	0.2615 „
phosphate of lime . . .	0.0004 „
phosphate of alumina . .	0.0002 „
phosphate of soda . . .	0.2615 „
fluoride of calcium . . .	0.0016 „
bicarbonate of lime . . .	2.6678 „
bicarbonate of magnesia .	2.5586 „

bicarbonate of protoxide of iron	0.1088 grains
bicarbonate of manganese	0.0032 „
bromide of sodium . . .	0.0002 „
silica	0.2500 „
	33.4054 grains.

2. *Gases.*

Carbonic acid	30.0100 cubic inches
nitrogen	0.0285 „ „
oxygen	0.0046 „ „
	30.0431 cubic inches.

At Obersalzbrunn, in Silesia, two springs are used for drinking and two for bathing. The following is, according to Professor Fischer, the chemical composition of the two former:—

1. *Solids.*

	Oberbrunnen. 45°—47°.75.	Mühlbrunnen. 45°—47°.75.
Carbonate of soda . .	8.81 grains	8.09 grains
chloride of sodium . .	1.12 „	0.62 „
sulphate of soda . . .	3.98 „	2.61 „
carbonate of lime . .	2.02 „	2.12 „
carbonate of magnesia	1.00 „	1.88 „
carbonate of protoxide of iron	0.07 „	0.04 „
silica	0.26 „	0.30 „
	18.60 grains.	15.66 grains.

2. *Gases.*

Free carbonic acid . .	37.50 cub. inch.	33 cub. inch.

According to a previous analysis by M. Struve, the springs also contain small quantities of sulphate of potash, carbonate of lithia, carbonate of strontia, and phosphate of alumina. These ingredients have been found neither by Professor Fischer nor by Dr Valentiner, who subsequently searched for them; at the same time infinitesimal quantities of rare elements found in springs cannot be considered of physiological or therapeutical importance. The composition of these and similar waters may be much modified by letting the carbonic acid escape, either partly or entirely; this may be easily done by letting the water stand for a while, or by warming it. By either of these means the carbonate of lime, of magnesia and of protoxide of iron become insoluble.

The two springs used for bathing are of a different chemical composition, namely: —

carbonate of soda	1.58	grains
sulphate of soda	0.62	„
chloride of sodium	0.23	„
carbonate of lime	1.63	„
carbonate of magnesia	0.32	„
carbonate of protoxide of iron	0.10	„
	4.48	grains.

These baths accelerate the metamorphosis of matter, promote the absorption of exudations in the skin and cellular tissue, and reduce congestion of internal organs.

The springs of Luhatschowitz, in Moravia, are ex-

ceedingly rich in bicarbonate of soda and chloride of sodium, and somewhat resemble the ido-bromated muriated springs, by their containing a considerable amount of chlorides, bromides and iodides. The following is their chemical composition, according to Ferstl:—

1. *Solids.*

	Vincenzbrunnen. 47°.75.	Amandibrunnen. 45°.7.
Carbonate of soda . .	23.263 grains	36.038 grains
chloride of sodium . .	23.527 „	25.753 „
bromide of sodium . .	0.255 „	0.101 „
iodide of sodium . . .	0.132 „	0.129 „
carbonate of lithia . .	0.009 „	0.014 „
carbonate of magnesia .	0.422 „	0.568 „
carbonate of baryta . .	0.070 „	0.064 „
carbonate of lime . . .	4.684 „	4.819 „
carbonate of strontia .	0.093 „	0.115 „
carbonate of protoxide of iron	0.111 „	0.135 „
chloride of potassium .	1.795 „	1.595 „
silica	0.395 „	0.107 „
	54.850 grains.	69.52 grains.

2. *Gases.*

Free carbonic acid . .	50 cub. inches.	29 cub. inches.

1. *Solids.*

	Johannbrunnen. 45°.7.	Louisenquelle. 48°.6.
Carbonate of soda	44.216 grains	43.211 grains
chloride of sodium . . .	27.889 „	33.479 „

	Johannbrunnen. 45°.7.	Louisenquelle. 48°.6.
chloride of potassium . .	2.142 grains	1.618 grains
bromide of sodium . . .	0.074 „	0.089 „
iodide of sodium	0.170 „	0.182 „
carbonate of lithia	0.015 „	0.013 „
carbonate of magnesia . .	0.551 „	0.512 „
carbonate of baryta . . .	0.049 „	0.067 „
carbonate of lime	4.895 „	4.407 „
carbonate of strontia . .	0.078 „	0.120 „
carbonate of protoxide of iron	0.095 „	0.183 „
silica	0.414 „	0.476 „
	80.76 grains.	84.44 grains.

2. *Gases.*

Free carbonic acid .	16 cubic inches.	14 cubic inches.

The water used for bathing at Luhatschowitz, has the following chemical composition:—

1. *Solids.*

Carbonate of soda	24.135 grains
chloride of sodium	20.878 „
chloride of potassium	1.856 „
bromide of sodium	0.113 „
iodide of sodium	0.354 „
carbonate of magnesia . . .	0.429 „
carbonate of lime	4.793 „
carbonate of protoxide of iron	0.156 „
silica	0.146 „
	59.73 grains.

2. *Gases.*

Carbonic acid	28 cubic inches.

The waters of Ems are the only thermals of this class, and are, on account of their high temperature, useful in many cases where cold springs of a similar character are not applicable. *Bronchitis* is frequently cured at Ems, especially if caused by cold, and if cough in the morning and evening is the most troublesome symptom. In cases of this kind, the Kesselbrunnen which contains less carbonic acid than the Krähnchen, is chiefly appropriate; but if the former should prove too exciting, it should be mixed with milk or whey. In children who suffer from bronchitis after measles or hooping-cough, and in adults where there is some inflammatory irritation, the Fürstenbrunnen is preferable. Ems is also eminently useful in that form of catarrh which is frequently observed in gouty persons, and sometimes alternates with true paroxysms of gout. Such patients suffer from cough, chiefly at night and if the weather is damp and cold; they also complain of asthma and dyspnoea, and the expectoration is copious and tenacious. By a course of Kesselbrunnen water, and thermal baths, they are generally improved or cured. In all cases where there is a tendency to congestion to the lungs, haemoptoe, and tuberculosis, Ems ought not to be prescribed, as it would aggravate these conditions.

Selters water is also beneficial in bronchitis, but only after the inflammatory irritation has subsided, and if there is relaxation of the mucous membrane. This water acts most powerfully if drunk at the place itself, as in the exported water the bicarbonate

of protoxide of iron is precipitated, and therefore becomes useless.

The springs of Obersalzbrunn have a special reputation in cases of bronchitis connected with haemorrhoidal complaints. In such patients the cough is at first dry and hollow, and afterwards the secretion becomes very tenacious. The paroxysms of cough are chiefly troublesome in the morning, and only cease after the expectoration of considerable quantities of tough mucus. Patients suffering at the same time from portal plethora, and having a full and high pulse, are much benefitted by the use of the Oberbrunnen, of Salzbrunn. The carbonic acid and iron contained in this water invigorate the system, while the carbonate and sulphate of soda alter the secretion of the mucous membrane, excite the action of the bowels, and thus improve abdominal circulation. The air in this place is keen and dry, and therefore suitable for persons with catarrh, but dangerous to consumptive patients with great irritability of the lungs. The water is often mixed with asses, goat's, and cow's milk, or with whey, which latter is very excellent at Salzbrunn.

The springs of Luhatschowitz are chiefly to be recommended in that form of catarrh which is observed in scrofulous patients. This place is protected from cutting winds by the mountains surrounding it, and the climate is mild, and rather moist than dry. The Johannesbrunnen is the spring generally used for bronchial catarrh, and the water is often mixed with whey made of sheep's milk.

Patients suffering from catarrh of the bronchial tubes, the stomach and the intestines, are also often sent to Gleichenberg, in Styria, where they may take the Constantinsquelle or the Johannisbrunnen. These springs have, according to Schröter, the following chemical composition:—

1. *Solids.*

	Constantinsquelle. 61°.25.	Johannisbrunnen. 56°.75.
Carbonate of soda . . .	19.298 grains	13.418 grains
chloride of sodium . .	14.241 „	4.475 „
carbonate of lime . . .	2.728 „	4.907 „
carbonate of magnesia .	3.205 „	3.866 „
carbonate of protoxide of iron	0 „	0.185 „
sulphate of soda . . .	0.658 „	0 „
silica	0.406 „	0.369 „
	40.536 grains.	27.220 grains.

2. *Gases.*

Free carbonic acid	35.5 cubic inches.	22.6 cubic inches.

In *catarrh of the larynx* which is due not to any constitutional distemper, but to over-exertion of the voice, as is often the case in clergymen, teachers, singers &c., the Kesselbrunnen and Krähnchen, either pure or mixed with milk and whey, are very useful. In *pharyngo-laryngitis granulosa*, where the catarrh chiefly affects the follicles of the mucous membrane, which then assumes a granular appearance in conse-

quence of hypertrophy of the follicles, inhalation of the gases which ascend from the springs of Ems, and which consist chiefly of carbonic acid and nitrogen, is much recommended by Dr Spengler. A special pavilion for the purpose of inhalation exists at Ems in which a jet of mineral water is constantly thrown up by means of a steam-engine, and the water being changed into spray, the gases escape and may by means of tubes, be applied to the suffering parts. Ventilation is well carried out in this room, and the comfort of the patients during the operation fully attended to.

Although the waters of Ems are generally prejudicial in cases of *haemoptoe*, there are certain forms of this affection in which they may prove useful. This is the case with women who suffer from haemoptoe after suppression of the catamenia, or during and after involution. In such cases the Kesselbrunnen is especially suitable.

Emphysema of the lungs cannot be cured by any mineral water whatever; but some of the troublesome symptoms arising from this disease may be greatly alleviated by the use of the muriated alkaline springs, especially by those of Ems. Dyspnoea is relieved, expectoration promoted, and the abdominal circulation improved. In cases of this kind the pure and mild air of this place is no doubt greatly instrumental in effecting an amelioration of the condition of the patients.

In *tuberculosis of the lungs* the muriated alkaline acidulous springs have a great, but by no means well founded reputation as curative agents. They are no doubt

serviceable for many patients suffering from cough, irritation of the larynx, oppression on the chest, and difficult and scanty expectoration; but experience has fully shown that, if there are physical signs of tubercular infiltration, the use, especially of the thermals of Ems, is dangerous, and should under no circumstances be advised, as haemoptoe, febrile symptoms, and an aggravation of the disease altogether would be the consequence. The Oberbrunnen, of Salzbrunn, has been much used in the incipient stage of consumption; but the climate of that place is, generally speaking, far too rough for patients of this kind. At all events, if they go, they should avoid bathing and fatiguing excursions into the mountains, and only drink the water mixed with milk or whey. The water should on no account be taken in the evening, as the disposition to haemoptoe is thereby increased. The Constantinsquelle, of Gleichenberg, would be far preferable in such cases, as the climate of that place is very mild. Care must however be taken, that part of the carbonic acid contained in this water is allowed to escape before it is drunk.

In *catarrh of the stomach*, especially if is not of very long standing, the Krähnchen, of Ems, and baths at a temperature of 88° to 92°, are very useful. The springs of Selters, which contain more chloride of sodium and a certain amount of carbonate of iron, are even more powerful in their effects than the Ems waters. Luhatschowitz is to be recommended, if the catarrh is dependent upon disturbances in the

abdominal circulation. The Johannbrunnen, of Gleichenberg, may be also employed in cases of this kind, and may after some time be succeeded by the use of the Klausnerbrunnen, an acidulous chalybeate of the same place, which contains 0.660 grains of bicarbonate of protoxide of iron, and 25 cubic inches of carbonic acid, but scarcely any salines. If the catarrh of the stomach is, however, a concomitant symptom of ulcer, the water should be altogether deprived of carbonic acid before being used, as the ructus which this gas often induces, might cause a lesion of continuity of the stomach.

In chronic catarrh of the intestines, in which diarrhoea alternates with constipation, and where there is rather a disturbed circulation and secretion than true atony of the bowels, the thermals of Ems frequently prove beneficial. During their use a judicious diet ought to be observed. Solid food is to be avoided, and beef-tea, eggs and light wines should form the chief nourishment of the patient. After a course of the Salzbrunn waters, certain entozoa, especially taenia and nematodes, are often evacuated.

Certain cases of *catarrh of the hepatic ducts*, with impeded excretion of bile, and icterus, may also be cured by a judicious use of the muriated alkaline acidulous Spas. The mucus is fluidified, the ducts again become pervious, concrements are discharged, and if the waters are continued for some time, a new formation of gall-stones may be prevented.

If dilatation of the *haemorrhoidal veins* with con-

sequent affections of the nerves, inflammation of the mucous membrane, and haemorrhage, arise from pressure upon the mesenteric veins by stercoral matters, and other causes of abdominal plethora, the cold Spas of this class are frequently useful; butthe patients ought to continue their use every year, as these affections are very apt to return. In most cases of the kind mentioned, however, the springs of Carlsbad, Marienbad, and Kissingen, which contain a larger amount of saline ingredients, are preferable to the muriated alkaline acidulous Spas.

In *chronic catarrh of the bladder*, the thermals of Ems have an equally favourable action as the Vichy water, and are preferable to the latter if the patients are of delicate constitution, and for whom the Vichy waters would be too potent. The cold Spas of this class are in this affection far inferior to the warm springs of Ems.

Gravel and renal calculi are frequently discharged during the use of the Kesselbrunnen, of Ems. The formation of such calculi is, in the majority of cases, probably due to a catarrh of the pelvis renalis, which is cured by the water, so that the cause of the disease is removed, after which the pain nd spasms disappear. In cases where the high temperature of the Ems water, and the large quantity of carbonic acid contained in most cold Spas of this kind, might prove too exciting, the new soda-lithia spring of Weilbach is applicable. This contains, according to Fresenius, in sixteen ounces of water: —

1. *Solids.*

Carbonate of soda	7.3748	grains
chloride of sodium	9.6677	„
sulphate of soda	1.7173	„
sulphate of potash	0.4233	„
bromide of sodium . . .	0.0056	„
iodide of sodium	0.0010	„
carbonate of lithia	0.0452	„
carbonate of iron	0.0193	„
carbonate of manganese .	0.0039	„
carbonate of lime	0.7504	„
carbonate of magnesia . .	0.5563	„
silica	0.0943	„
	20.6581	grains.

2. *Gases.*

Carbonate of ammonia . .	0.0871	grains
carbonic acid	5.9553	„
sulphuretted hydrogen . .	0.0026	„
	6.0450	grains.

The temperature of this spring is 54°.5. The tables of analyses of urine passed by patients before, during and after, the use of this Spa, and which have been published by Dr Stifft*, show that the discharge of uric acid concrements is favoured, the quantity of uric acid in the urine diminished, and uric acid sediments entirely disappear under the use of this water, while gouty affections of the joints, which are at the same time present, are improved.

* Deutsche Klinik. March and April 1862. p. 137.

In gout the internal use of the Kesselbrunnen, of Ems, proves beneficial if true paroxysms of gout do not take place, and the patients are weak and suffer from irritability of the nervous system. Where the dyspeptic symptoms are very prominent, and no considerable deposits have been formed in the joints, the Amandibrunnen, of Luhatschowitz, is an excellent remedy.

The Ems waters possess the reputation of being almost a panacea for chronic parenchymatous metritis (chronic infarctus of the womb). This disease has sometimes its origin in acute metritis, but is more frequently due to hyperaemia of the womb arising from disturbances in the abdominal and pelvic circulation. The vaginal portion and the cervix uteri are in such instances generally dark-red, hyperaemic, hypertrophied, and either painful to the touch or not; the whole tissue of the uterus being harder and firmer than it is in healthy women. In many cases there is also displacement of this organ, and dysmenorrhoea or amenorrhoea are mostly present. The mucous membrane of the cavity of the uterus secretes a considerable quantity of a puriform mucus, and the cervix uteri is filled with transparent mucus. Sterility, cardialgia, habitual sickness and vomiting, constipation, and various hysterical symptoms are generally the consequence of this condition of the womb. All these symptoms are often relieved by the Ems waters, and more especially by the use of the Bubenquelle (see p. 298) which is administered in the form of the ascending douche, but is only applicable to married

women. In applying it, great caution is necessary, and the temperature of the water, and the force of the jet should be suited to the constitution of the patient and the degree of the affection. If the ascending douche cannot be borne, the internal use of the Krähnchen and the Kesselbrunnen, and baths of the thermal water, not unfrequently prove useful. In youthful persons with a sluggish disposition, and where the uterus requires a powerful stimulus, the Krähnchen is preferable, while the Kesselbrunnen is chiefly suitable if the affection partakes of a somewhat inflammatory character.

The ascending douche and the baths of Ems are also useful in anomalies of menstruation, especially in the commencement of puberty, and after cold. In haemorrhage from the uterus connected with abdominal plethora and swelling of the liver, the baths and the internal use of these waters, frequently prove beneficial. In leucorrhoea, especially if it occurs in scrofulous patients, and when catarrh of the stomach and bronchi is at the same time present, the springs of Luhatschowitz, used externally and internally, often effect a cure.

Hysterical convulsions and paralysis, when due to irritation of the womb and adjacent organs, may be cured by the douche or the baths of Ems; the temperature of the latter should be very low in cases of this kind, and the treatment ought to be continued for at least two months, if permanent benefit is desired.

The Spas of this class may also be used with ad-

vantage in certain diseases of the skin, such as eczema in young women suffering from difficult menstruation, and certain cases of prurigo. In chronic conjunctivitis with loosening and relaxation of the mucous membrane &c., fomentations with the thermal water of Ems are much employed; but for these and similar complaints, other and more efficacious remedies are to be found in the materia medica.

In conclusion, I will add the analysis of the waters of Sinzig and Roisdorf, which are also to be recommended in the above mentioned diseases. The spring of Sinzig, near Remagen, in the valley of the Ahr, contains in sixteen ounces:—

1. *Solids.*

Carbonate of soda . .	8.05	grains
chloride of sodium . .	17.98	„
carbonate of lime . .	1.39	„
carbonate of magnesia	1.56	„
sulphate of soda . . .	0.29	„
silica	0.42	„
	29.69	grains.

2. *Gases.*

Carbonic acid	10.01	volumes.

The waters of Roisdorf, in Rhenish Prussia, are very similar to the foregoing. According to Bischof, they contain in sixteen ounces:—

1. *Solids.*

	Trinkquelle.	Stahlquelle.
Carbonate of soda . .	6.04 grains	1.38 grains
chloride of sodium . .	14.60 „	3.86 „
carbonate of lime . .	2.16 „	2.18 „
carbonate of magnesia	3.06 „	1.03 „
carbonate of protoxide of iron	0.05 „	0.20 „
silica	0.12 „	0.70 „
	29.70 grains.	10.53 grains.

2. *Gases.*

Carbonic acid . . . . 19 cubic inches.

III. ALKALINE SALINE WATERS.

The most frequented Spas of this class are the cold springs of Marienbad and Rohitsch, and the thermals of Carlsbad, Bertrich, and Ofen.

At Marienbad, there are seven alkaline springs which are therapeutically used, and within an area of seven miles, 124 acidulous springs rise from coarse-grained granite and mica-slate. Those most extensively employed are the Kreuzbrunnen and the Ferdinandsbrunnen, which have, according to Kersten, the following chemical composition:—

	Kreuzbrunnen. 53°.3.	Ferdinandsbrunnen.
Sulphate of soda . . .	36.269 grains	38.766 grains
bicarbonate of soda. .	12.394 „	13.999 „

	Kreuzbrunnen. 53°.3.	Ferdinandsbrunnen.
chloride of sodium . .	11.166 grains	15.397 grains
sulphate of potash . .	0.449 „	0.499 „
bicarbonate of lithia .	0.077 „	0.110 „
bicarbonate of lime . .	6.630 „	6.021 „
bicarbonate of strontia	0.017 „	0.008 „
bicarbonate of magnesia	5.399 „	5.299 „
bicarbonate of protoxide of iron	0.482 „	0.653 „
bicarbonate of protoxide of manganese . . .	0.053 „	0.166 „
phosphate of alumina .	0.054 „	0.014 „
phosphate of lime . .	0.018 „	0.015 „
silica	0.679 „	0.741 „
	73.736 grains.	81.515 grains.

Both these springs also contain traces of bromides, fluorides, crenates, apocrenates, organic substances, and extractive matter; and the Kreuzbrunnen 7.424, and the Ferdinandsbrunnen 14.800, grains of carbonic acid. The Waldquelle and Wiesenquelle of the same place have a very different chemical composition; they contain in sixteen ounces:—

1. *Solids.*

	Waldquelle. 43°.25.	Wiesenquelle.
Sulphate of soda . . .	5.228 grains	0.883 grains
bicarbonate of soda .	5.107 „	0.704 „

	Waldquelle. 43°.25.	Wiesenquelle.
chloride of sodium . .	2.116 grains	0.369 grains
sulphate of potash . .	1.495 „	0 „
bicarbonate of lithia .	0.009 „	0 „
bicarbonate of lime . .	2.725 „	6.516 „
bicarbonate of magnesia	0 „	4.373 „
bicarbonate of protoxide of iron	0.187 „	0.373 „
bicarbonate of protoxide of manganese . . .	0.035 „	0.161 „
phosphate of alumina .	0.011 „	0 „
silica	0.507 „	0.691 „
	20.091 grains.	14.070 grains.
2. *Gases.*		
Carbonic acid	13.509 „	12.828 „

The Marienquelle, of the same place, is poor in solid ingredients, but rich in carbonic acid, to which latter its action must be chiefly ascribed; this spring is chiefly used for bathing, and contains in sixteen ounces:—

1. *Solids.*

Sulphate of soda	0.353 grains
chloride of sodium	0.048 „
bicarbonate of magnesia	0.061 „
bicarbonate of lime	0.436 „
bicarbonate of protoxide of iron	0.035 „
silica	0.189 „
crenates, apocrenates, and organic matter	0.075 „
	1.197 grains.

2. *Gases.*

Free carbonic acid . . . . 9.056 c. inch.

This spring has a temperature of 52°.8 to 54°.5.

On comparing the analyses of the several springs of Marienbad, it will be seen that the Kreuzbrunnen which contains a very large amount of sulphate of soda, is somewhat similar to the bitter-waters; but it is distinguished from them by containing carbonate of soda, carbonic acid and carbonate of iron. These ingredients have the effect of accelerating the circulation and increasing the retrogressive metamorphosis of matter, while at the same time the system is not so much weakened as is done by the use of the stronger bitter-waters.

The Ferdinandsbrunnen contains even a larger amount of salines, carbonic acid, and iron, than the Kreuzbrunnen. Its purgative effects are therefore more considerable and it is also apt to produce congestions, so that it is chiefly suitable for persons of a torpid disposition, who have no tendency to congestion, and in whom a powerful action upon the bowels is desired. The Waldquelle, on the other hand, contains only a comparatively trifling amount of sulphates, so that it is not a strong purging water. It is useful in the milder forms of abdominal plethora and in catarrh of the respiratory organs, where it diminishes cough and promotes expectoration. The Wiesenquelle is not an alkaline saline spring, properly speaking, but rather belongs to the group of earthy springs, it being somewhat analogous to

the Wildungen water, and appropriate for the same cases as the latter. There are two other important springs at Marienbad, viz. the Ambrosiusquelle and the Carolinenquelle, which contain a considerable amount of iron, and belong to the chalybeate group. They are therefore employed in anaemia, and also often prescribed for patients who have been lowered by the use of the Kreuzbrunnen or Ferdinandsbrunnen.

According to Ragsky, the mineral moor of Marienbad, if thoroughly dried, contains in a thousand parts:—

1. *Substances soluble in water.*

Sulphate of potash	8.87	grains
sulphate of soda	6.05	„
sulphate of lime	4.15	„
sulphate of magnesia . . .	2.24	„
sulphate of alumina	0.96	„
sulphate of protoxide of iron	4.93	„
crenic acid	4.65	„
silica	0.92	„
soluble organic matter . . .	2.53	„
hydrate	0.58	„
loss	1.54	„
	37.33	grains.

2. *Substances insoluble in water.*

Sulphide of iron	22.50	grains
phosphate of peroxide of iron	13.68	„
hydrate of peroxide of iron	229.21	„
lime	2.14	„
magnesia	1.45	„

silica	1.50	grains
humic acid	107.14	„
carbon	42.46	„
wax	23.32	„
resin	4.02	„
other minerals	6.45	„
organic matter	508.80	„
	962.67	grains.
	37.33	„
	1000.00	grains.

The moor, if freshly dug up, contains:

water	813.76	grains
soluble matter .	6.95	„
insoluble matter	179.29	„

The springs of Tarasp and Scuols, in Lower Engadin, closely resemble the springs of Marienbad, and are probably destined to occupy a prominent place amongst the Spas of Europe. Up to the present time, however, there are scarcely any bathing establishments in existence there. The waters issue in a narrow and rocky hollow of the valley of the Inn, 4300 feet above the sea, which has until quite recently been only accessible to the horseman and foot-passenger; but a good road is now in course of construction. Although the elevation of the spot is very considerable, the climate is mild in summer, and the place is by the mountains protected from cutting winds. On an area of about one square mile, there rise no less than twenty mineral springs there; the most important amongst which are the

Grosse Quelle and the Kleine Quelle, which contain, according to Dr von Planta, in sixteen ounces of water: —

1. *Solids.*

	Grosse Quelle. 37°.		Kleine Quelle. 37°.	
Sulphate of soda . . .	16.547	grains	16.417	grains
carbonate of soda . .	27.229	„	28.535	„
chloride of sodium . .	29.401	„	29.381	„
carbonate of magnesia	5.076	„	4.977	„
carbonate of protoxide of iron	0.152	„	0.140	„
carbonate of lime . .	12.432	„	12.402	„
iodide of sodium . . .	1.536	„	0	„
sulphate of potash . .	2.998	„	3.337	„
silica	0.247	„	0.092	„
phosphoric acid . . .	0.002	„	0	„
alumina	0.002	„	0	„
fluoride and manganese	traces	„	0	„
	95.623	grains.	95.280	grains.

2. *Gases.*

Carbonic acid	34.887	„	33.271	„

The gases which ascend from the spring, consist of:

Carbonic acid	99.34	grains	99.21	grains
nitrogen	0.43	„	0.53	„
oxygen	0.23	„	0.26	„
	100	grains.	100	grains.

The Tempelbrunnen, of Rohitsch, in Styria, contains, according to Schrötter, in sixteen ounces:—

1. *Solids.*

	48°.8—52°.	
Sulphate of soda	15.546	grains
carbonate of soda	5.839	„
carbonate of lime	11.874	„
carbonate of magnesia	9.931	„
carbonate of protoxide of iron	0.695	„
chloride of sodium	0.726	„
silica	0.146	„
alumina	0.034	„
	44.191	grains.

2. *Gases.*

Carbonic acid in 100 cubic inches . 51 cubic inches.

At Carlsbad, innumerable hot springs rise from granite. The temperature of those most extensively used is as follows:

Sprudel and Hygieaquelle	162°.5
Bernhardsbrunnen	141°.6
Neubrunnen	137°.75
Stefansbrunnen	132°.8
Mühlbrunnen	126°.5
Theresienbrunnen	122°.4
Schlossbrunnen	122°
Marktbrunnen	119°.3
Kaiserbrunnen	117°.9

The Sprudel, of Carlsbad, has the following chemical composition:—

1. *Solids.*	According to Göttl 1852. grains.	Struve 1834. grains.	Berzelius 1823. grains.
Sulphate of soda. . .	19.9606	19.222	19.869
carbonate of soda . .	9.0624	10.141	9.695
chloride of sodium . .	8.7245	8.05	7.976
sulphate of potash . .	0.3696	0.718	0
carbonate of lime . .	2.0198	2.593	2.37
carbonate of magnesia	0.3994	1.764	1.37
carbonate of protoxide of iron	0.0307	0.047	0.028
phosphate of alumina	0.2150	0.002	trace
silica	1.0520	0.608	0.577
	45.8340	42.588	41.927

2. *Gases.*		
Carbonic acid	7.8033 cubic inches.	6.697
nitrogen	0.0318 „ „	

The Schlossbrunnen of the same place contains in sixteen ounces of water:—

1. *Solids.*	According to Steinmann 1823.	Göttl 1852.
Sulphate of soda . . .	15.3798 grains	10.145 grains
carbonate of soda . . .	8.8534 „	8.555 „
chloride of sodium . .	7.5264 „	8.463 „
sulphate of potash . . .	3.0325 „	11.558 „

	According to Steinmann 1823.		Göttl 1852.	
carbonate of lithia . .	0.0160	grains	0	grains
carbonate of strontia .	0.0033	„	0	„
carbonate of lime . . .	2.3984	„	2.419	„
carbonate of magnesia .	1.1770	„	0.299	„
carbonate of protoxide of iron	0.0234	„	0.023	„
carbonate of protoxide of manganese . . .	0.0049	„	0	„
phosphate of lime . . .	0.0060	„	0	„
phosphate of alumina .	0.0065	„	0.031	„
fluoride of calcium . .	0.0152	„	0	„
silica	0.4486	„	0.43	„
	38.8968	grains.	42.199	grains.

2. *Gases.*

Carbonic acid	17.3767	cubic inches.
nitrogen	0.0632	„ „

The Theresienbrunnen contains neither sulphate of potash, nor carbonates of lithia, strontia, manganese, magnesia, nor phosphates of lime and alumina, nor fluoride of calcium; but almost exactly the same quantity of sulphate and carbonate of soda, chloride of sodium and carbonate of lime as the Schlossbrunnen.

The Marktbrunnen differs from its fellows chiefly by a certain amount of iodide and bromide of sodium. It contains according to Wolf (1838):—

1. *Solids.*

Sulphate of soda	17.9919	grains
carbonate of soda	9.4553	„
chloride of sodium	8.3298	„
iodide of sodium	0.0209	„
bromide of sodium	0.0133	„
sulphate of potash	1.9603	„
phosphate of soda	0.0100	„
fluoride of sodium and silicium . . .	1.4288	„
carbonate of lithia	0.0100	„
carbonate of strontia	0.0377	„
carbonate of lime	2.1418	„
carbonate of magnesia	1.8987	„
carbonate of protoxide of iron . . .	0.0890	„
carbonate of protoxide of manganese	0.0185	„
alumina and peroxide of iron	0.0251	„
silica	1.3271	„
	43.8881	grains.

2. *Gases.*

Carbonic acid	11.7602	cubic	inches.
nitrogen	0.0530	„	„

The alkaline saline water of Bertrich, near Coblentz, contains, according to Mohr, in sixteen ounces:—

1. *Solids.*

	90°.5.	
Sulphate of soda . . .	7.0726	grains
chloride of sodium . .	3.3415	„
carbonate of soda . .	1.4183	„

	90°.5.	
carbonate of lime . .	0.6252	grains
carbonate of magnesia	0.4939	„
alumina	0.0292	„
silica	0.1844	„
barègine	0.3180	„
	13.4841	grains.

2. *Gases.*

Carbonic acid	17.32	volumes.

The Trinkquelle, of Ofen (Buda), which has a temperature of 140°, contains, according to Sigmund, in sixteen ounces:—

1. *Solids.*

Sulphate of soda	2.95	grains
carbonate of soda . . .	2.02	„
chloride of sodium . . .	0.82	„
carbonate of magnesia .	0.46	„
carbonate of lime . . .	3.12	„
silica	0.69	„
alumina	0.18	„
	10.51	grains.

2. *Gases.*

Carbonic acid . . . . . 5.72 cubic inches,
traces of sulphuretted hydrogen and nitrogen.

Patients suffering from disturbances of abdominal circulation are those most frequently sent to the alkaline saline Spas. Such disturbances may be caused by tumours in the abdomen, diseases of the heart and large vessels,

and emphysema of the lungs; and if these disorders are present, only temporary relief can be expected from the waters of this class. But if the stagnation of blood is owing to habitual constipation, pressure from accumulated faeces, and certain diseases of the liver, the Spas mentioned frequently prove curative. In consequence of disturbed abdominal circulation, a host of symptoms may ensue, such as general adiposity, swellings of the liver and spleen, chronic metritis, catarrh of the bladder and retention of the urine, haematuria, hyperaemia of the lungs and bronchial catarrh, headache, vertigo, tinnitus aurium, hyperaemia of the choroidea, and disturbances of vision; all of which generally disappear, if the abdominal circulation is fully re-established. Catarrh of the stomach and the intestines, with sickness in the morning, and alternating constipation and diarrhoea, in consequence of excessive eating, drinking and smoking, is often cured by the Kreuzbrunnen, of Marienbad, and the Schloss- and Mühlbrunnen, of Carlsbad. If such catarrh is of very long standing, and there is infiltration and thickening not only of the mucous membrane of the stomach, but also of the submucous connective tissue and the musculosa, the Sprudel, of Carlsbad, is preferable. The Schloss- and Theresienbrunnen, of the same place, have been much praised as remedies for ulcer of the stomach; but the benefit which in such cases is sometimes derived from a cautious use of these springs, is entirely owing to a removal of the catarrh of the stomach which generally accompanies ulcer.

In cases of abdominal plethora, the action of the skin is generally very sluggish; and baths of mineral water are therefore an excellent auxiliary to a cure. While the patient is in the bath, the abdomen should be well rubbed and kneaded, and after the bath a fair amount of exercise taken. Moor-baths, or moor-cataplasms, are also very suitable in cases of this kind. The moor used at Carlsbad is darkbrown, devoid of smell and taste, and has only a slightly fatty feel. If moistened with ordinary water, it reddens blue litmus-paper; but if Sprudel-water is added to it, it does not alter the colour of either the red or blue litmus-paper. In a thousand parts of moist moor, Pleischl found 655.5 parts of water and 344.5 parts of solid ingredients; of the latter, 197.7 were fixed, and 146.8 combustible. The minerals contained in this moor are chiefly sulphate of lime and magnesia, and peroxide of iron and manganese. According to Lehmann, the moor only acquires curative powers by weathering, when insoluble substances are rendered soluble by certain chemical decompositions being brought about. It is therefore advisable to employ only thoroughly weathered moor for baths and cataplasms. If used for baths, it is softened by adding so much hot water to it that it assumes the consistency of a thin paste; and the temperature of the bath is generally from 96° to 98°. In such baths, the body is able to bear a far higher amount of heat than in ordinary water or mineral water baths. The patient should, while sitting in it, continually bring fresh layers of moor in contact with the

suffering parts; at the same time, the latter should be gently rubbed. The duration of the bath varies from half an hour to three quarters of an hour. On leaving it, the patient takes a warm water bath, in which he must however only remain long enough to clear the skin from any adhering moor. Moor-baths may be taken daily or every other day; in the latter case alternately with the mineral water baths.

The Sprudel, of Carlsbad, is an excellent remedy for certain diseases of the liver; viz. hyperaemia arising from abdominal plethora and unconnected with disorders of the heart and lungs, or, from ague, in persons living in marshy districts. In most cases of the latter kind, the spleen is likewise affected, and even if the disease is very severe, a cure is often brought about by the use of this water. The same may be said of fatty degeneration of the liver, when not combined with other structural diseases, and granulated liver in its first stage, when this organ has not yet become atrophic. Exudations remaining after an acute inflammation of the liver, are often absorbed under the influence of this treatment; but in cancer of that organ, or in liver-disease due to syphilis, no benefit can be expected from Carlsbad or any other Spa.

Icterus, when arising from catarrh of the hepatic ducts, gall-stones, or hyperaemia of the liver, is often cured by Carlsbad and Marienbad, while, in cases which are consequent upon granulated liver in the second stage, cancer, and other tumours pressing upon the ducts, the use of the waters must be avoided. The dis-

charge of gall-stones during the administration of the Carlsbad water, is an event of very frequent occurrence; and D^r de Castro has recorded a case in which, after a three days' use of that water, 270 gall-stones of the size of small peas, were passed within twenty-four hours. Similar effects are also often produced in renal calculi and gravel.

In diabetes, the waters of Carlsbad fully deserve a fair trial. We know of no radical cure of diabetes by this treatment, but the experience of the last ten years has shown that in a number of cases, after the use of the Sprudel, all morbid symptoms have entirely disappeared for a considerable time, and the patients been temporarily restored to perfect health. Cases which are most likely to be benefited by Carlsbad water, are such in which there is complication with gout and liver disease. In patients of delicate constitution, the treatment should be commenced with the springs of a somewhat lower temperature, and the Sprudel should only be prescribed some time afterwards.

In habitual constipation due to sedentary habits, the same Spa is an excellent remedy. It has a mild, but certain effect upon the bowels, and which is much more permanent than that produced by strong purgative waters.

Great and lasting effects may also be expected from the springs of Carlsbad in those forms of gout in which abdominal plethora, hyperaemia of the liver, and catarrh of the stomach, are prominent symptoms. If there are deposits in the joints, the internal use of the Sprudel

should be combined with baths of the mineral water, or moor-baths. By these the pain is relieved, and the absorption of the exudation promoted. To prevent relapses, the patients should always, on their return home, continue to take the Carlsbad water internally. In those forms of gout I have just alluded to, the springs of Bertrich, in Rhenish Prussia, where a most excellent bathing establishment exists, are also very efficacious. The thermal springs of Ofen are chiefly employed for bathing, and prove beneficial in gout, rheumatism ,and chronic diseases of the skin. They contain only a small quantity of solid ingredients, and can therefore not be expected to produce such considerable effects as those of Carlsbad. The same may be said of the alkaline saline spring of Füred, on the Plattensee, which is suitable for the milder forms of abdominal plethora; and the internal administration of which is generally combined with cold bathing in the Plattensee, which proves very invigorating, especially for persons of sedentary habits.

The water of Rohitsch is to be recommended in dyspepsia with excessive acidity in the stomach. In this affection the earthy carbonates are very efficacious by neutralising the acid. As the quantity of sulphate of soda contained in it, is comparatively small, Rohitsch water has a far less powerful action upon the bowels than Marienbad, and is therefore only appropriate in the milder forms of abdominal plethora.

The question often arises, whether a patient had better be sent to Vichy, Carlsbad, Marienbad, or Tarasp, as all these springs may promise to be equally beneficial

in certain cases. From Vichy, Carlsbad is distinguished by the absence of any considerable amount of carbonic acid, and by the presence of sulphate of soda. The function of the stomach is therefore more excited by Vichy than by Carlsbad water: and, on the other hand, the latter can be advantageously used in subacute catarrh of the stomach and the intestines, in which the former is sure to do harm. By the sulphate of soda it contains, Carlsbad water acts more powerfully upon abdominal circulation than Vichy water. Marienbad is preferable to Carlsbad in cases where an accumulation of faecal matters is the cause of the disease, and a thorough clearing of the bowels is advisable; and also for stout persons who suffer from the effects of too generous living; while Carlsbad is superior to Marienbad in subacute catarrh of the stomach and the intestines, in which carbonic acid cannot be borne, or where, by the same gas, congestions might be produced in remote organs; and also for persons of a more delicate constitution. Amongst the several Spas of this class, Carlsbad is the most appropriate in severe, but curable disease of the liver; in icterus arising from gall-stones and liver disease; in diabetes, renal calculi, and tumours of the spleen. Tarasp is, by its chemical composition and the low temperature of the water, more closely allied to Marienbad than to Carlsbad, and may be employed with advantage in all cases in which Marienbad is suitable.

IV. BITTER-WATERS.

The best-known Spas of this class are those of Püllna, Saidschütz, Sedlitz, Friedrichshall, Kissingen, Ivanda and Gran. The composition of the Bohemian and Hungarian bitter-waters being very variable, they ought to be used with special caution.

The bitter-waters of Saidschütz and Sedlitz contain in sixteen ounces of water:—

	Saidschütz, according to Berzelius.		Sedlitz, according to Steinmann.	
Sulphate of magnesia	84.1666	grains	79.55	grains
sulphate of soda . .	46.8109	„	17.44	„
nitrate of magnesia	25.1715	„	0	„
carbonate of lime .	0	„	5.29	„
carbonate of magnesia	4.9858	„	0.20	„
carbonate of strontia	0	„	0.009	„
crenate of magnesia	1.0667	„	0	„
sulphate of lime . .	10.0776	„	4.14	„
sulphate of potash .	4.0965	„	4.41	„
chloride of magnesium	2.1696	„	1.06	„
carbonate of protoxide of iron and manganese	0.0192	„	0.05	„
silica	0.0360	„	0.05	„
iodide of magnesium	0.0368	„	0	„
	178.6282	grains.	112.199	grains.

and traces of fluorine and bromide of magnesium.

The bitter-water of Saidschütz is chiefly remarkable for the large quantity of nitrate of magnesia found in it, and from which, together with the sulphates, the water derives its cooling, diuretic, and antiphlogistic powers. The water of Sedlitz contains especially sulphate of magnesia, but the quantity of this is exceedingly variable.

The following is the chemical composition of the bitter-waters of Püllna, in Bohemia, and of Ivanda, near Temesvar, in the Banate: —

	Püllna, according to Struve.		Ivanda, according to Ragsky.	
Sulphate of soda . .	123.800	grains	117.343	grains
sulphate of potash .	4.800	„	0.112	„
sulphate of lime . .	2.600	„	25.997	„
carbonate of lime .	0.770	„	2.302	„
sulphate of magnesia	93.086	„	0	„
chloride of magnesium	16.666	„	14.609	„
carbonate of magnesia	6.406	„	0.209	„
nitrate of magnesia .	0	„	2.864	„
phosphate of lime .	0.003	„	0	„
phosphate of protoxide of iron	0	„	0.008	„
silica	0.176	„	0	„
extractive matter . .	0	„	1.131	„
	248.307	grains.	164.759	grains.

Püllna water is, by the very considerable amount of sulphates it holds in solution, rendered highly indigestible. It should only be used if a very rapid action upon

the bowels appears necessary; and one tumblerful in the morning, and another in the evening, are quite sufficient to effect this purpose. If the use of this water is continued for some time, digestion is greatly disturbed and the blood much impoverished. Ivanda water is similar to the foregoing, inasmuch as it also contains a large quantity of sulphate of soda; but as it does not contain any sulphate of magnesia, it is not nearly so powerful as Püllna water, and may be taken for some time without too greatly weakening the system.

The waters of Gran, in Hungary, are the most powerful of this class. They contain from 359 to 718 grains of sulphate of magnesia, and are therefore scarcely fit for medical use.

The bitter-water of Friedrichshall, near Coburg, contains in sixteen ounces:—

1. *Solids.*

	according to Bauer.	according to Liebig.
Sulphate of soda . . .	41.73 grains	46.51 grains
sulphate of magnesia .	39.55 "	39.55 "
chloride of sodium . .	67.37 "	61.10 "
chloride of magnesium	31.08 "	30.25 "
chloride of ammonium	0.06 "	0 "
chloride of aluminium	0.07 "	0 "
bromide of magnesium	0.02 "	0.37 "
sulphate of potash . .	0.02 "	1.52 "
sulphate of lime . . .	11.24 "	10.34 "
carbonate of lime . .	0.11 "	0.11 "
carbonate of magnesia .	3.53 "	1.16 "
silica	0.21 "	0.33 "
	194.99 grains.	190.25 grains.

2. *Gases.*

Carbonic acid	5.32 cubic inches.

The bitter-water of Kissingen contains, according to Liebig, in sixteen ounces: —

1. *Solids.*

Sulphate of soda . . .	46.51 grains
sulphate of magnesia .	39.55 „
chloride of sodium . .	61.10 „
chloride of magnesium	30.25 „
chloride of ammonium	0.02 „
chloride of lithium . .	0.09 „
	177.53 grains.

2. *Gases.*

Carbonic acid	5.9 cub. inch.

The "old well", of Leamington, contains, according to a somewhat questionable analysis, in a pint of water: —

1. *Solids.*

Chloride of sodium . .	40.770 grains
sulphate of soda . . .	40.398 „
chloride of calcium . .	20.561 „
chloride of magnesium	3.266 „
	105.195 grains.

2. *Gases.*

Carbonic acid	2 cub. inches.

The physiological effects of the bitter-waters have been fully described in the fourth chapter. We have seen that they act both as purgatives and diu-

retics, and they may therefore be used advantageously in a large number of cases in which it is advisable to excite the action of the bowels and the kidneys. If there is a considerable accumulation of faeces, or congestions towards the head and the lungs, large doses, viz. from one to two pints, may be taken at short intervals. In cases of abdominal plethora, in pregnant women, or when due to sedentary habits, disease of the heart, and indulgence in the pleasures of the table, one tumblerful in the morning, and another in the evening, are sufficient, and can be continued for some time without weakening the system. The action of the intestines is thereby regulated, and the consequences of abdominal plethora are prevented. The bitter-water of Ivanda has also proved of great service to the practitioners in the Banate, in cases of ague which is endemic in that district. As diuretics, the waters may be given in certain cases of dropsy, and pleuritic and other exudations. Finally, the bitter-waters, especially those which contain not only sulphates, but also a somewhat considerable amount of chloride of sodium, have proved eminently useful in scrofula, especially in swellings of the cervical glands, tumours of the cellular tissue, chronic inflammation of the mucous membranes, and eruptions of the skin.

There are two waters of this class in England which deserve a far more extensive trial at the hands of the medical Profession of this country than has hitherto been given them; as they are, by their chemical composition, admirably suited for the treatment of many

cases of disease, and may perhaps even prove superior to the continental Spas of this class. These are the bitter-water of Cherry Rock, near Kingswood, in Gloucestershire, and the Purton Spa, near Swindon, in Wiltshire. The former contains, according to the analysis of Mr T. J. Herapath, in the imperial pint (8794.4 grains):—

1. *Solids.*

Sulphate of magnesia	16.219	grains
sulphate of soda	15.345	„
chloride of sodium	7.603	„
iodide of sodium	0.009	„
chloride of potassium	0.105	„
chloride of magnesium . . .	0.060	„
bromide of sodium	traces	„
sulphate of lime	9.390	„
nitrate of lime	0.012	„
apocrenate of magnesia . . .	0.203	„
crenate of magnesia	0.145	„
nitrogenous organic matter .	2.999	„
carbonate of lime	3.967	„
carbonate of magnesia, iron, and phospate of lime	traces	„
alumina	0.120	„
bituminous matter	traces	„
	56.176	grains*.

2. *Gases.*

Free carbonic acid	4.124	cubic inches.

* or 48.92 grains in sixteen ounces of water.

The Purton Spa, although long known to the inhabitants of the neighbourhood, has only quite recently been brought under the notice of the Medical Profession*. It contains, according to Dr Voelcker, in an imperial gallon:—

1. *Solids.*

	58°.5.	
Sulphate of soda	112.239	grains
sulphate of magnesia	77.208	„
sulphate of lime	83.873	„
sulphate of potash	1.916	„
carbonate of potash	28.880	„
chloride of sodium	34.297	„
iodide of sodium	0.066	„
bromide of magnesium . . .	0.092	„
silica	1.280	„
oxide of iron, alumina, and traces of phosphoric acid	0.280	„
organic matter and water of combination	8.750	„
	348.881	grains**.

2. *Gases.*

Carbonic acid	50.4 cubic inches.
sulphuretted hydrogen . . .	trace.

* S. C. Sadler, Analysis of the Purton sulphate and tobromiodated saline water &c. 1860. — R. H. Bakewell, ad visit to he Purton Spa &c. 1861.

** An imperial gallon is equal to nine pounds and half an ounce of water, so that the amount of solids contained in sixteen ounces of this water, is 38.63 grains.

The combination of salines and carbonic acid in the two last-named English waters is peculiarly valuable, and it is a matter of surprise that they have up to the present time been so little used. The Purton Spa is in so far superior to that of Cherry Rock, as it also contains carbonate of potash, whereby the diuretic effects are increased. In my opinion, little or no value can be attached to the bromine and iodine contained in the Purton water, the quantity of these substances being exceedingly small; but its effects are no doubt chiefly due to the sulphates, the chloride of sodium and the carbonate of potash, while carbonic acid serves to render the water palatable and agreeable to the stomach. I am not aware whether the water of Cherry Rock is at present at all medically employed; that of Purton has for the last few years been used in diseases of the skin, certain abdominal affections and other diseases, in which a mild purgative and diuretic, which is well borne by the stomach and does not weaken the system, is generally appropriate. The two waters mentioned are probably destined to occupy a foremost position amongst all English mineral waters.

V. SIMPLE MURIATED WATERS.

Muriated waters are chiefly efficacious in gout, rheumatism, scrofula, and abdominal plethora. The most renowned Spas of this class are those of Wiesbaden, Baden-Baden, and Bourbonne-les-Bains, to which may be added those of Dipso and Thermia in Greece, all of

which are thermals; the waters of Soden, Mondorf, and Canstatt, which are tepid; and those of Kissingen, Homburg, and Cheltenham, which are cold.

At Wiesbaden, twenty-three muriated thermal springs rise from the slate of the Taunus, the most important amongst them being the Kochbrunnen, which has a temperature of 155°.75, and contains, according to Fresenius, in sixteen ounces:—

1. *Solids.*

Chloride of sodium	52.50	grains
chloride of potassium	1.12	„
chloride of lithium	0.001	„
chloride of ammonium	0.13	„
chloride of calcium	3.62	„
chloride of magnesium	1.57	„
bromide of magnesium	0.03	„
sulphate of lime	0.69	„
silica	0.46	„
carbonate of lime	3.21	„
carbonate of magnesia	0.08	„
carbonate of protoxide of iron	0.04	„
carbonate of protoxide of manganese	0.004	„
phosphate of lime . . . . . ,	0.003	„
arseniate of lime	0.001	„
silicate of alumina	0.004	„
	63.46	grains.

2. *Gases.*

Carbonic acid	16.72	cubic inches.
nitrogen	0.10	„ „

The gases ascending from the Kochbrunnen consist of

carbonic acid .	79.8 volumes
nitrogen . . .	20.2 „
	100 volumes.

The Hauptquelle, of Baden-Baden, which has a temperature of 155°.7, contains, according to Professor Bunsen:—

1. *Solids.*

Chloride of sodium	16.520 grains
bicarbonate of lime	1.273 „
bicarbonate of magnesia	0.042 „
bicarbonate of protoxide of iron	0.037 „
bicarbonate of protoxide of manganese	traces
bicarbonate of ammonia	0.051 „
sulphate of lime	1.556 „
sulphate of potash	0.017 „
phosphate of lime	0.021 „
arseniate of iron	traces
chloride of magnesium	0.097 „
chloride of potassium	1.258 „
bromide of sodium	traces
silica	0.914 „
alumina	0.008 „
nitrates	traces
	22.093 grains.

2. *Gases.*

Free carbonic acid. . . . . 0.299 grains.

The composition of the Fontaine Chaude, at Bourbonne-les-bains, which has a temperature of 149°, is, according to M. Chevallier, the following:—

Chloride of sodium . .	46.110	grains
chloride of calcium . .	5.683	„
bromide of potassium .	0.384	„
carbonate of lime . . .	2.264	„
sulphate of lime. . . .	5.993	„
	61.471	grains.

The thermal springs of Aedepsos (Dipso), in Euboea (Negroponte), resemble in their chemical composition those of Wiesbaden, from which they are, however, distinguished by the sulphuretted hydrogen found in them. They contain, according to Landerer, in sixteen ounces:—

1. *Solids.*

Chloride of sodium . . .	68.00	grains
chloride of magnesium .	3.50	„
chloride of calcium . . .	2.00	„
sulphate of magnesia . .	5.70	„
sulphate of soda	1.50	„
carbonate of soda . . .	0.80	„
*iodide of sodium	0.50	„
*bromide of magnesium .	0.48	„
silica	0.9	„
	82.57	grains.

* The method used by M. Landerer for ascertaining the quantity of iodine and bromine being faulty, the numbers given for these two substances cannot be considered correct. Another chemist has only found traces of iodine and bromine in the above springs.

2. *Gases.*

Carbonic acid	2 cubic inches
sulphuretted hydrogen .	0.5 „ „

The temperature of the several springs of Dipso ranges between 88° and 162°. A strongly mineralised mud is used at this place for cataplasms.

The muriated springs of the island of Thermia (Greece) have a temperature of 116° and contain, according to M. Landerer, in sixteen ounces:

1. *Solids.*

Chloride of sodium . . .	51.6 grains
chloride of magnesium . .	13.5 „
chloride of calcium . . .	3.5 „
carbonate of lime	1.5 „
carbonate of soda	0.8 „
sulphate of magnesia . .	9.0 „
*bromide of magnesium . .	1.2 „
*iodide of magnesium . . .	0.6 „
silica	traces
extractive matter	traces
	81.7 grains.

2. *Gases.*

Carbonic acid	3 cubic inches.

Twenty-three muriated springs issue at Soden, in Nassau. Amongst these the most important are the Milchbrunnen, the Warmbrunnen, the Wilhelmsbrunnen

* Probably incorrect.

and the Soolbrunnen, and of which Liebig has given the following analysis:—

1. *Solids.*

	Milchbrunnen.	Warmbrunnen.
Chloride of sodium	17.68 grains	26.13 grains
chloride of potassium . . .	0.16 „	1.29 „
sulphate of lime	0.19 „	0.25 „
carbonate of lime	2.73 „	4.47 „
carbonate of magnesia . . .	1.37 „	2.63 „
carbonate of protoxide of iron	0.16 „	0.30 „
alumina	0.01 „	0 „
silica	0.16 „	0.23 „
	23.46 grains	35.30 grains

2. *Gases.*

Carbonic acid	17 c. i.	35.9 c. i.

1. *Solids.*

	Wilhelmsbrunnen.	Soolbrunnen.
Chloride of sodium . .	104.10 grains	114.40 grains
chloride of potassium .	2.53 „	3.52 „
sulphate of lime . . .	0.98 „	0.76 „
carbonate of lime . . .	8.38 „	8.63 „
carbonate of magnesia .	1.28 „	0.29 „
carbonate of protoxide of iron	0.30 „	0.60 „
alumina	0.05 „	0.88 „
silica	0.30 „	0.50 „
	117.92 grains.	129.58 grains.

2. *Gases.*

Carbonic acid	48.9 cub. inch.	14 cub. inch.

The muriated springs of Mondorf, near Luxembourg, and of Canstatt, near Stuttgardt, contain in sixteen ounces:—

1. *Solids.*

	Mondorf, accord. to Kerkhoff. 77°.		Canstatt, accord. to Fehling.	
Chloride of sodium . .	66.98 grains		19.50 grains	
chloride of potassium .	1.58	„	0.25	„
chloride of magnesium .	3.25	„	0.18	„
carbonate of lime . . .	0	„	7.38	„
carbonate of magnesia .	0.05	„	0.31	„
carbonate of protoxide of iron	0.22	„	0.25	„
sulphate of soda . . .	0	„	4.75	„
sulphate of magnesia .	0	„	2.25	„
sulphate of lime . . .	12.61	„	7.75	„
chloride of calcium . .	24.31	„	0	„
bromide of magnesium .	0.16	„	0	„
silica	0.05	„	0	„
	109.81 grains.		42.62 grains.	

2. *Gases.*

Carbonic acid	1.06 cub. inch.	19.4 cub. inch.
nitrogen	0.47 „	„

The following is the analysis, by M. Löwe, of the muriated springs of Kronthal, near Frankfort:—

1. *Solids.*

	Stahlquelle. 56°.75.	Wilhelmsquelle. 61°.25.
Chloride of sodium . .	22.27 grains	27.20 grains
chloride of potassium .	0.77 „	0.67 „
chloride of ammonium	0.07 „	0.04 „
chloride of calcium . .	0.07 „	0.16 „
carbonate of lime . .	4.17 „	5.10 „
sulphate of lime . . .	0.21 „	0.23 „
carbonate of magnesia	0.72 „	0.72 „
carbonate of protoxide of iron	0.05 „	0.10 „
carbonate of protoxide of manganese . . .	0.02 „	0.01 „
silica	0.66 „	0.55 „
organic matter	0.11 „	0.01 „
	29.16 grains.	35.26 grains.

2. *Gases.*

Carbonic acid	40 cub. inch.	33 cub. inch.

The Trinkbrunnen, of Meinberg, contains, according to Brandes, in sixteen ounces:—

Chloride of sodium	40.9571 grains
chloride of magnesium	6.3123 „
iodide of magnesium	0.0980 „
sulphate of soda	11.0129 „
sulphate of potash	0.0421 „
sulphate of lime	13.4629 „
carbonate of lime	6.0329 „

carbonate of magnesia	0.5171 grains
carbonate of protoxide of iron	0.0070 „
phosphate of alumina	0.0030 „
silica	0.0045 „
	78.4498 grains.

Baron Liebig has given the following analysis of the Ragoczi, Pandur, and Maxbrunnen of Kissingen:—

1. *Solids.*

	Ragoczi. 51°.	Pandur. 51°.	Maxbrunnen.
Chloride of sodium . .	44.71 gr.	42.39 gr.	17.52 grains
chloride of potassium	2.20 „	1.85 „	1.14 „
chloride of lithium . .	0.15 „	0.12 „	0.004 „
chloride of magnesium	2.33 „	1.62 „	0.51 „
bromide of sodium . .	0.06 „	0.05 „	0 „
iodide of sodium . . .	traces	traces	0 „
nitrate of soda	0.07 „	0.02 „	0.65 „
sulphate of magnesia .	4.50 „	4.59 „	0 „
sulphate of lime . . .	2.99 „	2.30 „	1.06 „
phosphate of lime . .	0.04 „	0.04 „	0.03 „
carbonate of lime . .	8.14 „	7.79 „	4.62 „
carbonate of protoxide of iron	0.24 „	0.20 „	0 „
silica	0.09 „	0.03 „	0.07 „
	65.70 gr.	61.30 gr.	28.10 grains.

2. *Gases.*

Carbonic acid	41.77 c.i.	48.17 c.i.	41.85 c.i.
ammonia	0.007 gr.	0.029 gr.	0

I now proceed to mention the chemical composition of the most important springs of Homburg:—

1. *Solids.*

	Elisabethbrunnen, according to Liebig. 50°.	Kaiserbrunnen, accord. to Hoffmann. 52°.25.
Chloride of sodium .	79.15 grains	104.94 grains
chloride of potassium .	0 „	0.28 „
chloride of magnesium	7.79 „	8.52 „
chloride of calcium .	0 „	17.50 „
carbonate of protoxide of iron	0.46 „	0.53 „
sulphate of lime . . .	0 „	0.17 „
carbonate of lime . .	10.99 „	0.68 „
carbonate of magnesia	2.01 „	0 „
sulphate of soda . . .	0.38 „	0 „
silica	0.32 „	0.09 „
	108.87 grains.	132.71 grains.

2. *Gases.*

Free carbonic acid . .	21.48 grains. (48.46 c. i.)	51.91 grains. (109.16 c. i.)

1. *Solids.*

	Ludwigsbrunnen, according to Hoffmann. 53°.3.	Stahlbrunnen, according to Liebig. 50°.
Chloride of sodium .	47.96 grains	79.86 grains
chloride of potassium .	1.71 „	0.18 „
chloride of magnesium	3.06 „	5.33 „
chloride of calcium .	7.28 „	10.67 „

sulphate of lime . . .	0.15 grains	0.15 grains
carbonate of lime . .	5.74 „	7.53 „
carbonate of magnesia	0.10 „	0 „
carbonate of protoxide of iron	0.42 „	0.94 „
silica	0.20 „	0.31 „
	66.63 grains.	104.97 grains.
2. *Gases.*		
Free carbonic acid. .	19.42 grains. (43.59 c. i.)	21.27 grains. (46.91 c.i.)

The Pitville strong saline water of Cheltenham contains, according to Messrs Abel and Rowney, in an imperial gallon:—

1. *Solids.*	
Chloride of sodium . .	481.1933 grains
sulphate of soda . . .	112.8666 „
carbonate of soda . . .	20.1481 „
carbonate of magnesia .	11.3897 „
sulphate of potash . . .	2.9512 „
bromide of sodium . .	3.2928 „
carbonate of lime . . .	7.7021 „
silica	2.7755 „
crenic acid	0.3591 „
organic substances . .	3.4993 „
	646.1777 grains.
2. *Gases.*	
Carbonic acid	16.254 cubic inches.
sulphuretted hydrogen	traces.

Sixteen ounces of this water, therefore, contain 48.118 grains of chloride of sodium, 11.287 grains of sulphate of soda, and 1.629 cubic inches of carbonic acid.

Unfortunately, the chemical composition of the Cheltenham waters is very variable, and some of them have at times been suddenly deprived of so large an amount of ingredients that they were no longer available for medical purposes. The quantity of carbonic acid in the Cheltenham waters is exceedingly small and they are therefore apt to disagree with the stomach.

In *gout* the waters of Kissingen prove useful by exciting the secretions of the intestines, kidneys, and the skin, and thereby reducing the habitual plethora, eliminating the gouty poison, and promoting a healthy metamorphosis of matter. Patients suffering from so-called irregular gout, where the joints are not much affected and no paroxysms take place, sometimes feel an increase in the severity of the symptoms during the first few weeks of the Kissingen treatment, when a paroxysm of gout occurs which lasts for a week or fortnight, after which the health improves rapidly. Cases of long standing, with structural lesions of the joints, the bones, the heart, and the blood-vessels, are generally more suitable for the thermals of Wildbad, Gastein, Teplitz, and Wiesbaden. The springs of Homburg have nearly the same effect in gout as those of Kissingen; but by their containing more carbonic acid, they prove more exciting. Their use may be advantage-

ously combined with brine-baths. The springs of Mergentheim and Canstatt are chiefly efficacious in irritable persons with gouty deposits in the joints as well as with irregular gout, and who have at the same time a tendency to congestions to the head and chest. In such cases, the sulphate of soda contained in the last-named waters acts very beneficially, while the quantity of carbonic acid found in them is too small to cause any excitement. During the progress of the treatment, the urine frequently shows strong sediments of urates, phosphates, and oxalates, the skin acts more freely, and eruptions are sometimes observed in it.

The thermals of Wiesbaden may be advantageously employed in almost all forms of gout, unless inflammatory symptoms should at the same time be present. In gouty diseases of the joints, contractions and anchyloses, the Wiesbaden waters prove just as effective, as in chronic catarrh of the stomach and intestines when occurring in gouty patients. By their use the elimination of uric acid from the blood is promoted, and the abdominal circulation improved. If however abdominal plethora is a very prominent symptom, Carlsbad should be prescribed previously to Wiesbaden water. In the majority of cases from two to four tumblersful of the Kochbrunnen are ordered. If it is intended to act chiefly on the kidneys, the water is allowed to cool, and is drunk at short intervals, at the same time only little exercise being taken; but if a diaphoretic effect is desired, the water is taken at its

natural temperature, and considerable walking exercise is enjoined. Regarding the baths I may remark that, if circulation is to be stimulated, secretion promoted, and the activity of the skin altogether increased, the temperature of the water should be about 93°, and their duration from ten minutes to half an hour; but if they are intended to diminish irritation without exciting the skin, the water should be of 83° to 88°, and the bath may last from half an hour to two hours. In the bath, the suffering parts should be well rubbed, and afterwards brushed; and on leaving it the patient should remain in bed for some time. During the Wiesbaden treatment, paroxysms of gout not unfrequently take place; but after these, the general health rapidly improves, and the patients are often for years free from any inconvenience. If stronger effects than those of the ordinary thermal baths are desired, vapour-baths may be taken:— the patient is placed up to the neck in a tub in which the thermal vapours are allowed to accumulate. The temperature of these varies from 110° to 132°, and the patient should stay in the bath from five minutes to half an hour. Vapour-baths may be taken daily or on alternate days, and be combined with the useof the douche. The temperature of the water employed for the latter generally varies between 84° and 120°, and the force of the jet and the duration of the application should be proportioned to the severity of the affection and the constitution of the patient.

The thermals of Baden-Baden may be recommended

in anomalous gout, especially if the patients are at all delicate or weakened by previous treatment. The water of these springs is seldom drunk; in its stead Kissingen Ragoczi, or Homburg Elisabethbrunnen are generally prescribed for internal use. The chief remedial agents of Baden-Baden are the baths, which are of a very excellent description. Vapour-baths, vapour-douches, and mud-cataplasms are also frequently employed. The effects of the muriated lithia waters of this place in gout will be mentioned hereafter. The waters of Bourbonne-les-Bains, in the Département of Haute-Marne, are suitable for gouty patients of torpid constitution. Two pints of the water are generally prescribed to be drunk before, during, and after the bath. In most cases it agrees well with the stomach, especially if a little milk or whey is added to it. If constipation should ensue, enemata should be taken in preference to purgatives. Baths of a temperature of 95° to 97°, a douche of 100° to 110°, and gas-baths of 100° to 120°, are also much employed there.

In chronic rheumatism, tic douloureux, and sciatica, the Wiesbaden waters frequently prove curative. Certain forms of paralysis are likewise amenable to this treatment. Many gouty patients suffer from peripheral paralysis arising from the pressure of exudations upon the nerves, and if these are absorbed, the paralysis disappears at the same time. In women suffering from paraplegia after parturition, and in rheumatic palsy, these waters are also useful. The same may be said of paralysis due to impaired circulation

in the lower part of the spinal cord. Baths and the douche are chiefly employed in such cases. Patients suffering from cerebral paralysis are often sent to Wiesbaden: but this Spa is not at all suitable for such affections.

The Maxbrunnen, of Kissingen, is an excellent remedy in scrofula, especially in the erethic form of this distemper. The Milchbrunnen and Warmbrunnen, of Soden, are also much prescribed for such cases, and they act beneficially by improving the digestion and invigorating the system generally. The waters of Mondorf which, besides the chloride of sodium, contain a not inconsiderable quantity of bromide of magnesium, may likewise be employed in the different forms of scrofula. Homburg is prescribed with advantage when this disease is combined with anaemia. If however the cases are of long standing, or the disease has a severe form, brines or iodated springs are in the majority of cases preferable.

For certain forms of indigestion, the Ragoczi and Pandur, of Kissingen, are admirable remedies. Their effects can scarcely be ascribed to the insignificant amount of iron found in them; but they are chiefly due to the carbonic acid and chloride of sodium contained in these springs. Patients suffering from ulcer or cancer of the stomach, should not be allowed to drink the waters of this place. But if the dyspepsia is owing to chronic catarrh of the stomach, liver disease, abuse of intoxicating liquors, or deficient secretion of gastric juice, arising from sedentary habits and other causes,

the internal use of the Ragoczi should be combined with warm brine-baths. If however there is any inflammatory irritation of the stomach, which is evidenced by great sensitiveness of that organ, cold acidulous muriated waters, such as those of Kissingen and Homburg, are not allowable; but small doses of the thermal water of Wiesbaden frequently exert a beneficial influence.

Chronic catarrh of the intestines and habitual constipation may be cured by the combined internal use of the Ragoczi and the bitter-water of Kissingen. According to Dr Erhard, certain parasites, especially the Botryocephalus latus, with which many patients coming from Russia, Poland, Finland, and the Eastern provinces of Prussia, are affected, are often discharged during the first few weeks of the Kissingen treatment. If the internal use of the Ragoczi is not sufficient to kill the worms, a small dose of the extract of male fern greatly aids the treatment. In chronic diarrhoea arising from intestinal catarrh, the Kochbrunnen, of Wiesbaden, is the best Spa of this class that can be chosen.

In abdominal plethora in weak, irritable, and scrofulous patients, to whom the use of the bitter-waters and of Marienbad might prove detrimental, the Ragoczi, or the Homburg Elisabethbrunnen, should be prescribed. If judiciously administered, these waters cause neither constipation nor relaxation of the mucous membrane of the intestines. The former is preferable if there is a disposition to vomiting and to congestions to the head, as in such cases the Elisabethbrunnen may, by its

carbonic acid and iron, prove too exciting; but where there is no such tendency, the latter is most admirably suited. After such patients have taken the Ragoczi for some time, they may drink the acidulous chalybeate of Brückenau, near Kissingen; and those who have used the Elisabethbrunnen, may afterwards take the Kaiserbrunnen, or Stahlbrunnen, of Homburg, which are true chalybeates, and tend to invigorate the system in a remarkable manner. The thermals of Wiesbaden are appropriate in the milder forms of abdominal plethora, where constipation, haemorrhoids, and hyperaemia of the liver are troublesome; but in severe forms of this disease, Carlsbad is preferable. If catarrh of the bronchial tubes is at the same time present, we may order the waters of Soden, or those of Canstatt, which contain a rather considerable amount of sulphates, whereby both the effects of the bitter-waters and the muriated springs may be produced. This peculiarity is even more strongly marked in the waters of Mergentheim, in Würtemberg, which form, as it were, the connecting link between the bitter-waters and the muriated springs, and contain 51.26 grains of chloride of sodium, 21.89 grains of sulphate of soda, 15.88 grains of sulphate of magnesia, and 9.5 cubic inches of carbonic acid. Amongst the English Spas, Cheltenham is the one most closely allied to Canstatt and Mergentheim; but as the Cheltenham water contains a far less considerable amount of carbonic acid than the two latter, these are, on the whole, decidedly superior to the former.

In abdominal plethora, bitter-waters are more suited

than muriated waters, more especially if there is obstinate constipation, due to over-indulgence in the pleasures of the table, and adiposity. But if abdominal plethora occurs in scrofulous persons, and if exudations are to be absorbed, the muriated waters deserve preference.

These Spas also often prove curative in catarrh of the larynx and the lungs. Those containing a moderate quantity of solids, as for instance the Maxbrunnen, of Kissingen, are generally better suited for cases of this kind than the strong muriated waters, which have in some instances been known to increase the cough and the other symptoms of catarrh. The Elisabethbrunnen is, on account of its iron and carbonic acid, chiefly fit for persons of a torpid constitution, and Wiesbaden for such with a gouty diathesis. The internal use of the latter in cases of this kind, requires to be regulated with particular care.

Muriated waters have been warmly recommended for consumptive patients. They cannot cure phthisis; but if patients affected with this disease suffer at the same time from troublesome catarrh, indigestion and disturbed nutrition, the Maxbrunnen, the Kronthal Wilhelmsquelle, and the Homburg Ludwigsbrunnen, may be taken with advantage for allaying the irritation of the mucous membrane of the respiratory organs, promoting digestion and giving tone to the system generally. A prolonged stay at Soden is very beneficial, as the climate is exceedingly temperate and not subject to sudden changes. The tranquillity of this place con-

trasts favourably with the noise and bustle of Baden-Baden, Wiesbaden, and Homburg, which Spas are centres of fashion and gambling, and on this account frequently prove ruinous to patients unable to bear excitement. The whey at Soden is excellent.

In certain diseases of the liver, the muriated springs are of great therapeutical value. In middle-aged patients who have a constitutional tendency to hyperaemia of the liver, arising from want of exercise, too generous diet, and accumulation of fat, the Ragoczi, taken together with the Kissingen bitter-water, frequently effects a cure; while cases in which the hyperaemia arises from disease of the heart or lungs, are hardly amenable to this treatment. It is true that even in a few instances of the latter description, relief has been afforded, but as most of the Kissingen waters are of an exciting character, great caution is necessary in prescribing them. It is much to be regretted that patients suffering from far-advanced heart-disease, who ought never to be sent to any Spa, are even nowadays frequently advised to resort to Kissingen, which they sometimes reach in such a state of exhaustion as to preclude the possibility of their returning home.

Icterus when due to catarrh of the mucous membrane of the duodenum, or to emotion, is generally cured by the internal use of Ragoczi. Gall-stones are, under the influence of the same waters, discharged, probably in consequence of the augmented secretion of bile washing out the excretory ducts of the liver, and the icterus disappears with its exciting cause. But

no good can be expected in jaundice consequent upon cancer, cirrhosis, and other disorganisations of the liver. Cases of simple induration and enlargement of this organ, may also be benefitted by the Kissingen treatment; which is however powerless in tumours, atrophy, and amyloid degeneration of the liver. In certain cases of enlargement of this organ, Homburg may be recommended; Soden is appropriate in fatty degeneration, especially in patients of torpid constitution, who may, after a few weeks' stay at this Spa, be sent to Schwalbach, to drink the chalybeates there. Where there is considerable tendency to congestion and inflammatory irritation, in plethoric and irritable persons, the springs of Canstatt are preferable.

Muriated Spas are likewise of value in certain diseases of the spleen, in which they may be employed internally and externally, together with mud-baths and mud-cataplasms. Dr Constantin James states that by the use of the waters of Bourbonne-les-Bains, not only tumours of the spleen, but even cases of ague which have resisted arsenic and quina, are cured. The experience made in the German Spas shows, that, if tumours of the spleen are due to ague or to suppressed catamenia or haemorrhoids, the Homburg and Kissingen treatment is often successful; but that, if the composition of the blood has much suffered, the use of muriated waters should be followed by that of saline chalybeates. It is scarcely necessary to remark that tumours of the spleen due to leukaemia and other incurable diseases, are not beneficially acted upon by any Spas.

In renal calculus and catarrh of the bladder, the administration of muriated waters is also often attended with favourable results. The Maxbrunnen and Theresienbrunnen, of Kissingen, which possess a considerable diuretic action, have a special reputation in such cases; they are sometimes preferable to alkaline acidulous waters, as they do not disturb digestion, but are easily borne even by persons with weak stomachs.

Chronic diseases of the skin connected with abdominal plethora, arthritic ulcers, and old gunshot-wounds, are often cured at Wiesbaden and Bourbonne-les-Bains, even if projectiles and pieces of necrotic bone are still present. These latter often pass away after the baths have been taken for some time, after which the ulcers heal. The waters should however only be prescribed some time after the accident, and when every trace of inflammation has disappeared: for if they are used in too early stages, unfavourable results may be obtained. The waters must also be avoided by persons who have suffered from fractures, and where union has only recently been effected. Whether the waters have a tendency to soften fibro-cartilaginous and osseous tissue, as has been asserted, is by no means settled; but it is a fact that recently-united bones often fracture again if these waters are used.

Muriated waters externally and internally employed, promote absorption, and may therefore be administered in swellings of the testicle, uterus, ovaries, mammae &c.; in cases of this kind, however, the iodo-bromated waters are generally preferable.

VI. MURIATED LITHIA WATERS.

The muriated lithia springs of Baden-Baden have only quite recently been employed in cases of gout and lithiasis, and there is consequently as yet no sufficient experience concerning their therapeutical powers. According to Dr Ruef, in almost all patients treated by these waters, the pain in the joints increased at first, but it never spread to healthy parts. In joints which were perfectly contracted, crackling, dragging and pulling was felt as if the articulation was being torn asunder; but after such an attack of pain, a sensation of easiness and decided improvement was perceived, and the mobility of the limb much increased. In one patient a regular fit of gout came on while drinking the water, under the continued use of which this patient so rapidly improved that he could walk about again after three days. Gouty affections of the joints, the sheaths of the nerves and muscles, if not of very long standing, were cured after three or four weeks. In periodically -recurring headache on one side, which is often due to gout, the effects were likewise beneficial. The mode of administering the water was as follows:—For patients with whom large quantities of water do not agree, five grains of the carbonate of lithia were added to a bottle of Murquelle, which contains five grains of chloride of lithium; and the water was then impregnated with carbonic acid. Of this one tumblerful was drunk three times a-day; and if an increase of the dose appeared necessary, two or three grains of the carbonate were

added to every glass. If patients are able to retain much water on the stomach, they may take six or eight tumblersful of Murquelle, without any artificial addition of carbonate of lithia. Baths with water of the same spring are also given, and a mother-lye is prepared from it which may be added to them.

The muriated lithia waters of Baden-Baden have, according to Professor Bunsen, the following chemical composition:—

	Murquelle.		Fettquelle.	
Chloride of sodium . .	15.5534	grains	16.9767	grains
chloride of lithium . .	2.3694	„	0.2315	„
chloride of potassium .	1.7985	„	0.8137	„
chloride of magnesium	0.8022	„	0.4406	„
chloride of calcium . .	0.5127	„	0	„
chloride of copper . .	0	„	traces	
bicarbonate of lime . .	0.9748	„	1.4760	„
bicarbonate of magnesia	0.2673	„	0.0112	„
bicarbonate of protoxide of iron	0.0029	„	0.0112	„
bicarbonate of protoxide of manganese . . .	traces		traces	
sulphate of lime . . .	1.8524	„	1.3390	„
sulphate of potash . .	0	„	0.3344	„
sulphate of strontia . .	0.0052	„	0	„
sulphate of baryta . .	0	„	traces	
ammonia	traces		traces	
arseniate of iron . . .	traces		0.0038	„
silica	0.3200	„	0.4477	„
	24.4538	grains.	22.1409	grains.

VII. BRINES.

Brines are mostly employed for bathing, and do much good in diseases caused by impaired nutrition and innervation, such as scrofula and anaemia, and in complaints in which any excitation of the skin is desirable, as for instance in rheumatism, certain forms of paralysis, and catarrh of the mucous membranes.

Amongst brines, those of Rehme, or Oeynhausen, in Westphalia, and Nauheim, in Hesse, have the greatest reputation as therapeutical agents. At Rehme, three springs are employed, viz. the thermal brine-spring, the Bülowbrunnen, and the Bitterbrunnen. The baths given at this Spa are of various kinds, viz. ordinary baths, wave-baths, froth-baths, local and general carbonic acid gas-baths, brine-baths, and baths with an addition of mother-lye. There are also inhalation rooms, in which the water is changed into spray, whereby the carbonic acid contained in it is set free and may be inhaled.

The thermal brine spring of Rehme has, according to Bischof, the following chemical composition:—

1. *Solids.*

Chloride of sodium	256.39	grains
chloride of magnesium	8.28	„
sulphate of lime	22.99	„
sulphate of potash	0.36	„
sulphate of magnesia	19.99	„
carbonate of lime	6.67	„
carbonate of magnesia	3.85	„

carbonate of protoxide of iron . . .	0.51	„
carbonate of protoxide of manganese	0.01	„
silica	0.35	„
	319.40 grains.	

2. *Gases.*

Carbonic acid . . . . 10.97 cubic inches.

The Bülowbrunnen, of Rehme, which is a cold brine spring and fit for internal use, contains, according to Gnüge, in sixteen ounces:—

Chloride of sodium.	180.63	grains
sulphate of soda.	16.19	„
carbonate of soda	7.39	„
carbonate of magnesia . . .	4.93	„
carbonate of lime	6.50	„
carbonate of protoxide of iron	0.05	„
silica.	0.01	„
	215.70	grains.

The proportion of gases to be found in this water has not yet been ascertained; it contains however a certain quantity of carbonic acid, by which it is rendered more pleasant to the taste and more agreeable to the stomach than it would otherwise be.

At Nauheim, five thermal brine-springs are therapeutically used. The water furnished by three large spouts (Sprudels) is employed for bathing, and that of two other brine-springs, the Curbrunnen and Salzbrunnen, is internally administered. This latter, however, requires to be diluted with about equal parts of fresh

water to become acceptable to the stomach. If thus modified, the composition of the Curbrunnen is somewhat similar to that of the Kissingen Ragoczi. Brine-baths, in which the water continually flows off and is again renewed; hip-baths, douches &c., are given at this Spa. The springs of Nauheim are distinguished from those of Rehme chiefly by their higher temperature, and by the larger amount of carbonic acid found in them. Some importance is also to be ascribed to the bromide of magnesium contained in the Curbrunnen, and of which no trace is found in the waters of Rehme. The following is the chemical composition of the springs of Nauheim, according to an analysis by M. Bromeis:—

1. *Solids.*

	Kleiner Sprudel. 74°.6.	Grosser Sprudel. 99°.9.
	grains.	grains.
Chloride of sodium	152.25	181.24
chloride of potassium . . .	2.07	4.02
chloride of calcium	13.17	14.86
chloride of magnesium . . .	2.67	2.60
bromide of magnesium . . .	0.08	0.07
carbonate of lime	14.13	16.38
carbonate of protoxide of iron	0.29	0.50
carbonate of protoxide of manganese	0.07	0.15
sulphate of lime	0.83	0.38
silica	0.10	0.06
	185.86	220.27

2. *Gases.*

Carbonic acid	12.92	7.02

The Kurbrunnen and Salzbrunnen, of the same place, contain in sixteen ounces of water:

1. *Solids.*

	Kurbrunnen. 71°.3. grains.	Salzbrunnen. 72°.5. grains.
Chloride of sodium	109.923	141.822
chloride of potassium	4.047	5.479
chloride of calcium	8.215	10.714
chloride of magnesium	2.155	2.102
bromide of magnesium	0.295	0.400
silica	0.115	0.153
sulphate of lime	0.740	0.775
bicarbonate of lime	11.558	11.904
bicarbonate of protoxide of iron	0.199	0.199
bicarbonate of protoxide of manganese	0.027	0.061
	137.22	173.607

2. *Gases.*

Carbonic acid	14.765	17.263

For most persons, there is nothing unpleasant in brine-baths. Even pregnant women bear them, on the whole, remarkably well, and several cases are on record in which women who had previously borne sickly children, gave birth to strong and healthy infants after a course of brine-baths during pregnancy. Caution is,

however, necessary if there is much irritability of the nervous system, as in a few cases of such character, abortion has been the consequence of their use.

Brines are excellent remedies for scrofula, especially in children and when there are no considerable local affections. If the patients are beyond the commencement of puberty, and large tumours of the glands exist, little benefit is to be expected; and if such patients have only begun to suffer at a somewhat later period of life, brines are useless. They also prove of little avail in scrofulous diseases of the skin; for although in the milder forms of eczema, pithyriasis and crusta lactea, and in skin-diseases subesquent upon eruptive fevers, benefit has sometimes resulted, these baths are powerless against the more severe forms of eczema, ichthyosis, and psoriasis.

Scrofulous affections of the mucous membranes are more amenable to this treatment. Thus in chronic bronchitis, and in patients having a tendency to repeated attacks of subacute bronchitis with abundant secretion, brine-baths often prove curative. The same may be said of ozaena, in which brine-vapour-baths should be chiefly used; but in this disease several courses of the treatment are almost always necessary. If the Eustachian tube participates in the affection of the Schneiderian membrane, brine-baths and the local application of the gas-douche, are often attended with favourable results. This treatment is also to be recommended in otitis externa, and catarrh and abscess of the external and middle ear; while it is of no use in

caries of the petrous portion of the temporal bone. Catarrh of the vagina in scrofulous and anaemic persons, is frequently improved or cured by brines; but they do no good in idiopathic or diphtheritic inflammation of that organ. The remedial powers of brines are often strikingly displayed in scrofulous diseases of the bones, such as caries, necrosis, osteoporosis, inflammation of the joints, and anchylosis, even if the constitution has already given way, and hectic fever should be present.

Brines are not advisable for patients suffering from phthisis, and Rehme should be particularly avoided by them, as the air of that place is too bracing. Patients affected with secondary syphilis have also sometimes been sent there. They experience no benefit whatever from the treatment; but, on the contrary, become so much worse, that in cases where the diagnosis is doubtful, these baths may be advised as a valuable means for recognising the nature of the disease.

Brine-baths have the reputation of being apt to produce congestion to the head, and apoplexy; but this is by no means the case, provided they are judiciously used. On the contrary, they frequently afford relief in certain forms of hyperaemia of the brain and paralysis after apoplexy, especially if the patients are not far advanced in age, and the affection not of too long standing. It is scarcely necessary to observe that no benefit can be expected from this treatment in softening of the brain, paralysis agitans, epilepsy, and chronic hydrocephalus. In paralysis from weakness of the spinal

cord, brines have sometimes been successfuly employed, but they should not be prescribed if there is any trace of inflammation of that organ. In cases of paralysis after typhoid fever, parturition, and eruptive fevers, Rehme, Nauheim, and other brines are excellent remedies. In these affections, and also in infantile paralysis, Faradisation of the suffering parts should be combined with the use of brines. The same may be said of hysterical and rheumatic paralysis, lead-palsy, and certain cases of reflex paralysis.

Brine-baths are also appropriate in certain forms of nervous asthma. They likewise promote the absorption of exudations consequent upon acute rheumatism; and may be taken with advantage in chronic rheumatism of the joints, muscles, and tendons. Rheumatic diathesis is often quite extinguished by their use, and atony of the skin, with tendency to taking cold, is cured. In gout, the general health of the patients may be improved and the absorption of exudations induced; but on the whole, brines are for gouty patients far less suitable than other Spas. Exudations after traumatic inflammation of the joints, pleurisy, hydrops bursarum &c., are frequently absorbed under the influence of this treatment.

In fibrous tumour of the uterus, the general health of the patients is almost always much improved by the use of brines; at the same time the tumour itself may become smaller, or its further growth arrested. There is one case of ovarian dropsy on record, in which the

extent of the tumour was greatly diminished by the use of Rehme.

Finally, brines are strongly to be recommended for decrepidity in old persons, and in such as have become prematurely old. They have also a favourable influence upon the evolution of those who have just attained the period of puberty, and upon that of the foetus.

Amongst the other brines which are extensively used, I may mention that of Achselmannstein, in Bavaria, where the establishments and arrangements for bathing are similar to those at Rehme and Nauheim. The climate of Achselmannstein is mild and healthy, and not relaxing in summer. The air being largely impregnated with saline particles, it is very similar to sea-air. Juice expressed from alpine herbs, and whey, are also much employed there. This Spa is chiefly resorted to by convalescents from severe diseases, scrofulous patients, and such as suffer from bronchitis. The Edelquelle, of this place, contains, according to Buchner, in sixteen ounces:—

1. *Solids.*

Chloride of sodium . . .	1723.10	grains
chloride of ammonium . .	0.19	„
chloride of magnesium . .	13.84	„
bromide of mangesium . .	0.23	„
sulphate of soda	15.63	„
sulphate of potash	4.70	„
sulphate of lime	31.98	„

carbonate of lime	0.07 grains
carbonate of magnesia . .	traces
peroxide of iron and alumina	0.06 „
silica	0.08 „
	1789.88 grains.

2. *Gases.*

Carbonic acid:—amount not determined.

This water it exceedingly potent, and therefore requires to be greatly diluted with fresh water in order to become fit for internal use; and when given, one tablespoonful of the brine is added to a tumblersful of ordinary water. One or two such doses may be taken every second or third day; but it is not allowable to administer the brine for several days in succession, as violent purging would be produced thereby. In most cases the quantity just mentioned is, on account of the carbonic acid contained in the water, easily borne; but in persons of weak and irritable constitution, its internal use is entirely prohibited. Even when used for bathing, the water of the Edelquelle requires to be previously diluted. At first, five quarts of brine are generally added to the bath, and this dose is gradually increased to thirty, fifty, and even eighty quarts.

The brine of Arnstadt, near Weimar, is also in great repute. It contains 1723 grains of chloride of sodium, and altogether 1825 grains of solid ingredients, in sixteen ounces of water. The climate of the place is healthy, the air rather bracing, and the variations of temperature not very great. In weak persons, ordinary

warm water baths to which bran is added, are employed before brine and mother-lye is used.

Ischl, in the Austrian Salzkammergut, is distinguished for its pure and bracing air and grand Alpine scenery. It is surrounded by mountains rising to a height of from 5000 to 6000 feet, and is not subject to any considerable variations of temperature. This place by its beauty alone exerts a wholesome influence upon patients; its only drawback is a somewhat considerable moisture in the air at certain times. The brine used there contains 223 grains of chloride of sodium, and altogether 238 grains of solid ingredients. Besides the brine-baths, brine-vapour-baths, mineralised mud-baths, and whey, are much employed. The Ischl treatment proves very beneficial in the milder forms of scrofula, more especially in children, and where there are no considerable local affections. In scrofulous diseases of the glands and bones, Ischl is of less use than other Spas, while it is most admirably suited for convalescents from severe diseases.

Hall, in the Tyrol, near Insbruck, where a brine and mother-lye is much employed; and Hall, in Würtemberg, are efficacious in the same class of cases in which Rehme and Nauheim are generally prescribed.

The brine of Jaxtfeld, in Würtemberg, contains 1963 grains of chloride of sodium in sixteen ounces, and is one of the strongest waters of this kind. It is chiefly used for baths, but may be rendered fit for internal administration by dilution with water and addition to it of milk or whey. This brine has a very power-

ful action upon the skin, and by reflex, upon remote organs.

The *Hubertusbrunnen*, at the foot of the Rosstrappe, in the Hartz Mountains, contains, according to Bauer, in sixteen ounces:—

1. *Solids.*

Chloride of sodium	114.904	grains
chloride of calcium	85.747	,,
chloride of magnesium . . .	0.187	,,
chloride of potassium	0.568	,,
chloride of lithium	0.111	,,
chloride of aluminium	0.416	,,
chloride of ammonium . . .	0.168	,,
chloride of strontium	0.726	,,
chloride of baryum	0.025	,,
carbonate of lime	0.581	,,
phosphate of lime	0.010	,,
nitrate of lime	3.330	,,
carbonate of protoxide of iron	0.005	,,
bromide of magnesium . . .	0.268	,,
iodide of magnesium	0.002	,,
silica	0.269	,,
	207.321	grains.

2. *Gases.*

Carbonic acid	0.439	cubic inches.

The brine-springs of Wittekind, near Halle, contain in sixteen ounces, according to Steinberg:—

	Brine for baths. grains.	Brine for drinking. grains.
Chloride of sodium	238.464	230.469
chloride of magnesium . .	4.684	6.535
chloride of calcium . . .	3.138	4.661
sulphate of lime	7.756	7.465
carbonate of lime and carbonate of protoxide of iron .	0.005	0.007
	254.047	249.137

In order to make the water more acceptable to the stomach, it is artificially impregnated with carbonic acid; and for increasing the effects of the baths, the salines are extracted from the brine by evaporation, and added to the water. This "Wittekind-salt" consists of

Chloride of calcium . .	1176.945	grains
chloride of magnesium	2391.176	,,
chloride of sodium . .	908.851	,,
chloride of potassium .	283.822	,,
bromide of magnesium	61.386	,,
bromide of aluminium	10.422	,,
iodide of aluminium . .	1.928	,,
sulphate of lime . . .	14.400	,,
carbonate of lime . .	1.014	,,
carbonate of magnesia	0.637	,,
huminate of potash . .	18.040	,,
peroxide of iron . . .	12.157	,,
silica	3.549	,,
organic matter	8.217	,,
water	2787.456	,,
	7680	grains.

In one pound are contained

Iodine	1.779 grains
bromine . . . . . . , .	62.524 „

Baths to which Wittekind-Salt has been added, have much the same effects as those mixed with mother-lye.

VIII. IODO-BROMATED MURIATED SPRINGS.

Amongst the waters of this class, those of Kreuznach, Hall, Dürckheim, and Krankenheil, are most extensively employed. Kreuznach enjoys the most firmly-established reputation of all the iodo-bromated muriated waters. There are four springs at this place which are used for drinking and bathing; and graduated brine and mother-lye are much employed as additions to baths. The most important spring of Kreuznach is the Elisenquelle, which has a temperature of 54°.5 and is exclusively used for drinking.

The following is the chemical composition of the Elisenquelle and Oranienquelle, of Kreuznach:—

	Elisenquelle, according to Löwig. 54°.5.	Oranienquelle, according to Liebig. 54°.5.
Chloride of sodium . .	72.883 grains	108.705 grains
chloride of calcium . .	13.389 „	22.749 „
chloride of magnesium	4.071 „	0 „
chloride of potassium .	0.624 „	0.460 „
chloride of lithium . .	0.613 „	0 „

bromide of magnesium	0.278 grains	1.780 grains
iodide of magnesium .	0.035 ,,	0.012 ,,
carbonate of lime . . .	1.693 ,,	0.255 ,,
carbonate of magnesia.	0.106 ,,	0.130 ,,
carbonate of protoxide of iron	0 ,,	0.356 ,,
silica	0.129 ,,	0.999 ,,
phosphate of alumina .	0.025 ,,	0.095 ,,
	93.846 grains.	135.541 grains.

The graduated brine, of Kreuznach, contains, according to Dr Wiesbaden, in sixteen ounces:—

Chloride of sodium . . .	1311.89 grains
chloride of calcium . . .	241.00 ,,
chloride of magnesium .	73.22 ,,
chloride of potassium . .	11.23 ,,
bromide of magnesium .	5.00 ,,
iodide of magnesium . .	0.63 ,,
	1642.97 grains.

The mother-lye, of Kreuznach, contains, according to Polsdorf, in sixteen ounces:—

Chloride of calcium . . .	1789.97 grains
chloride of sodium . . .	226.37 ,,
chloride of magnesium .	230.81 ,,
chloride of potassium . .	168.31 ,,
chloride of aluminium . .	1.56 ,,
chloride of lithium . . .	7.95 ,,
iodide of sodium	0.05 ,,

bromide of sodium . . .	59.14 grains
perchloride of iron . . .	traces
sulphate of soda	traces
	2484.16 grains.

In the majority of cases, twenty to thirty ounces of Elisenquelle are prescribed to be taken daily, which dose is diminished for children in proportion to their age. An hour after drinking, a bath is taken, at a temperature of from 86° to 92°. For plethoric and irritable persons, this should be of a somewhat low temperature, while for children a rather warm bath is preferable. At first simple brine-baths are given, and mother-lye is only used after the system has become accustomed to them. The quantity of mother-lye added, varies from one to fifty and even a hundred quarts; this is gradually diminished as soon as symptoms of excitement and saturation of the system are observed, or if the desired result has been obtained. The duration of the bath varies from one quarter to three quarters of an hour; and in severe cases of scrofula, skin-diseases, &c., even two baths per diem are sometimes given. While the patient is in the bath, it is well to rub the suffering parts with a soft sponge or brush, and to keep the water in perpetual motion, which is the more important if it contains mother-lye; as this has a much greater specific gravity than ordinary brine, and is therefore apt to sink to the bottom of the tub. Sheets soaked in brine are also applied

to the suffering parts, especially in tumours of the lymphatic glands. Injections of the water are used in cases of otorrhoea, coryza, ozaena, and similar affections.

The Kreuznach treatment is chiefly successful in scrofulous infiltrations of the glands, where brines, such as Rehme, Nauheim, and others, fail to afford relief; also in scrofulous diseases of the skin, particularly lupus, sycosis, lichen, ichthyosis, and scrofulous ulcers; and even in caries and necrosis, a prolonged use of the waters not unfrequently proves curative. While brines are more beneficial in cases of short duration and in children, the effects of the Kreuznach waters are most striking in cases of long standing, and in scrofulous affections of adults. They are likewise to be recommended in chronic metritis and oophoritis, with consequent anomalies of menstruation and swelling of the ovaries; and in enlargement of the prostate and the testicle, when this is due to inflammation. In fibroid tumour of the uterus, the waters act, according to Scanzoni, chiefly by reducing the size of the womb, after which the troublesome symptoms which are owing to the enlargement of the organ, such as haemorrhage, uterine colics &c., disappear. In tumours of the ovaries, Scanzoni does not advise the use of these waters if the tumour is of a carcinomatous character, and so long as there are any symptoms of congestion; but in ovarian tumours of a different character, their further growth may be arrested or retarded. The waters are also efficacious

in tertiary syphilis, more especially in patients who have taken much mercury, and in whom syphilis is associated with scrofula.

The waters of Hall, in Austria proper, enjoy a special reputation in cases of bronchocele, and this water is therefore generally known as "Kropf-wasser". The Hauptquelle of this Spa contains, according to Netwald, in sixteen ounces:—

1. *Solids.*

Chloride of sodium	112.04	grains
chloride of potassium	0.049	,,
chloride of ammonium	0.033	,,
chloride of calcium	2.933	,,
chloride of magnesium	2.622	,,
iodide of sodium	0.061	,,
iodide of magnesium	0.285	,,
bromide of magnesium	0.518	,,
phosphate of lime	0.026	,,
carbonate of lime	0.480	,,
carbonate of magnesia	0.242	,,
carbonate of protoxide of iron	0.088	,,
silica	0.073	,,
	119.454	grains.

2. *Gases.*

Carbonic acid.	1.37	grains.

Unfortunately the quantity of water yielded by these springs is by no means large, and Kreuznach, Dürckheim and other Spas enjoy in this particular great ad-

vantages over Hall. According to D^r^ Rabl, the water proves rapidly curative in scrofulous swellings of the glands, if these are soft and of short duration; while if they are hard, insensible to pressure, and of long standing, repeated courses of the treatment are necessary. If suppuration and ulceration of such swellings has commenced, a cure is generally soon brought about. No benefit however is to be expected when almost all the external lymphatic glands are changed into voluminous tumours resembling fibrous cancer, and where there are at the same time affections of the spleen, and a leukaemic condition of the blood. In such cases the Hall water has a prejudicial action, and should never be employed. It often proves successful in the same class of skin diseases and syphilitic affections in which Kreuznach is efficacious; but is powerless against syphilitic diseases of the iris, choroidea, and the mucous membranes. D^r^ Rabl has seen a severe case of elephantiasis of the leg completely cured by the Hall treatment. In lymphatic bronchocele, where the thyroid body is infiltrated with colloid matter, favourable results may be expected from this Spa, while in other forms of this disease, the "Kropf-wasser" does not justify its name. In blennorrhoea of the uterus, vagina and urethra, injections of the water are appropriate.

The springs of Dürckheim, in the Palatinate, have only of late been used for therapeutical purposes, but they have rapidly acquired great reputation as remedies for scrofula and allied diseases. The air of this

place is dry and bracing, its situation open and sunny, and the temperature not subject to sudden changes. The springs contain in sixteen ounces:—

1. *Solids.*

	Virgiliusbrunnen.	Bleichbrunnen.
Chloride of sodium . . .	78.917 grains	71.011 grains
chloride of potassium . .	0.678 ,,	0.599 ,,
chloride of calcium . . .	13.824 ,,	14.914 ,,
chloride of magnesium .	3.783 ,,	1.812 ,,
chloride of aluminium . .	0.039 ,,	0.031 ,,
bromide of sodium . . .	0.193 ,,	0.151 ,,
iodide of sodium	0.019 ,,	0.014 ,,
phosphate of soda . . .	0.006 ,,	0.004 ,,
phosphate of alumina . .	0.002 ,,	0.001 ,,
sulphate of lime	0.168 ,,	0.251 ,,
bicarbonate of lime . . .	1.852 ,,	2.201 ,,
bicarbonate of magnesia .	0.059 ,,	0.064 ,,
bicarbonate of protoxide of iron	0.094 ,,	0.126 ,,
bicarbonate of protoxide of manganese	0.004 ,,	0.005 ,,
silica	0.081 ,,	0.084 ,,
alumina	0.0008 ,,	0.0007 ,,
crenates and apocrenates	0.003 ,,	0.005 ,,
	99.725 grains.	81.277 grains.

2. *Gases.*

Carbonic acid	3.980 c. inch.	4.741 c. inch.
nitrogen	0.640 ,,	0.810 ,,

For erethic persons baths only are ordered, while in torpid patients the water is also internally administered. The amount of foreign ingredients contained in these springs not being very large, they are chiefly to be recommended in the milder forms of scrofula. Graduated brine and mother-lye are commonly added to the baths, and in affections of the glands and joints, the douche proves an important auxiliary to the treatment.

The waters of Elmen, in Prussian Saxony, deserve to be favourably mentioned. The spring used for drinking contains 202 grains of chloride of sodium, 1.458 grains of bromide of magnesium, and altogether 224 grains of solid ingredients; that used for bathing contains 375 grains of chloride of sodium, 4.526 grains of bromide of magnesium, and altogether 412 grains of solid constituents; while in the mother-lye, according to Steinberg, not less than 1177 grains of bromide of magnesium, and altogether 2485 grains of solids are found. At this Spa, it is customary to carry a continuous stream of cold brine into the tub in which the patient is sitting, so that at last the temperature of the water becomes very low. The tubs are spacious, and exercise in the bath is therefore possible. Brine being however a worse conductor of heat than ordinary water, the amount of caloric thus withdrawn from the body is by no means so large as that given off in the ordinary water-bath. One to four quarts of mother-lye are, in severe cases, added to a bath. The brine is also, after having been diluted, used internally, when it acts as an aperient, and promotes absorption.

Brine vapour-baths are given in diseases of the respiratory organs.

The water of Wildegg, in Switzerland, is very useful for patients suffering from the torpid form of scrofula, and in most other cases in which Kreuznach and Hall prove beneficial. It contains, according to Löwig, in sixteen ounces:—

Chloride of sodium	75.264	grains
chloride of potassium	0.044	,,
chloride of calcium	2.866	,,
chloride of magnesium	12.387	,,
iodide of sodium	0.301	,,
bromide of sodium	0.006	,,
sulphate of lime	13.485	,,
carbonate of lime	0.637	,,
carbonate of protoxide of iron	0.003	,,
	104.993	grains.

M. Bauer, who has also made an analysis of these waters, discovered, besides the ingredients mentioned above, some acetate of magnesia in it. The Wildegg water owes its present reputation chiefly to Professor Schönlein, who prescribed it extensively together with acorn-tea.

The water of Castrocaro, in the Tuscan Romagna, contains, according to an analysis by Antonio Targioni Tozzeti, which I have reduced from twelve to sixteen ounces, the following ingredients:—

Chloride of sodium	404.36	grains
bromide of sodium	0.08	,,
iodide of sodium	1.20	,,
sulphate of soda	21.22	,,
carbonate of lime	5.66	,,
carbonate of magnesia	2.76	,,
small quantities of silica, carbonate of manganese, crenic acid, and naphtha	2.68	,,
	437.96	grains.

This water can only be used internally after having been greatly diluted with water; it has proved effective in the same diseases in which the other iodo-bromated waters are employed.

The Adelheidsquelle, in the village of Heilbrunn, in Bavaria, the water of which is exported in large quantities, but not used at the place where it rises, contains, according to Pettenkofer, in sixteen ounces:—

1. *Solids.*

Chloride of sodium	38.0684	grains
bromide of sodium	0.3678	,,
iodide of sodium	0.2199	,,
chloride of potassium	0.0200	,,
sulphate of soda	0.048	,,
carbonate of soda	6.2168	,,
carbonate of lime	0.5840	,,
carbonate of magnesia	0.1440	,,
carbonate of protoxide of iron	0.0720	,,

alumina	0.1424 grains
silica	0.1472 ,,
phosphate of lime	traces
organic matter	0.1648 ,,
	46.1953 grains.

2. *Gases.*

Carbonic acid	13.18 cub. inch.
carburetted hydrogen	8.02 ,, ,,
nitrogen	6.54 ,, ,,
oxygen	1.38 ,, ,,
	29.12 cub. inch.

The springs of Krankenheil, near Tölz, in Upper Bavaria, contain some sulphuretted hydrogen and only a very small amount of solid ingredients. There are four springs at that place, three of which are internally administered. The water is taken either pure or mixed with whey, and is also used for general and local baths. The salts and soaps prepared from the contents of the springs, have already been mentioned. It is scarcely possible to suppose that 0.009 grains of iodine and 1.494 grains of bicarbonate of soda, which are contained in sixteen ounces of one of the springs of Krankenheil, should exert a very powerful influence upon the system; and it is therefore probable that the curative effects of this Spa are chiefly to be ascribed to the water itself, and to the stay of the patients in an Alpine neighbourhood. The following is the analysis given by Fresenius of the springs of Krankenheil:—

1. *Solids.*

	Johann Georgquelle. 45° to 47°.	Annaquelle. 47°.
Chloride of sodium . . .	1.799 grains	0.232 grains
sulphate of potash . . .	0.094 ,,	6.167 ,,
sulphate of soda	0.095 ,,	2.253 ,,
iodide of sodium	0.012 ,,	0.009 ,,
bicarbonate of soda . . .	2.483 ,,	1.494 ,,
bicarbonate of lime . . .	0.703 ,,	1.917 ,,
bicarbonate of magnesia .	0.229 ,,	1.841 ,,
bicarbonate of protoxide of iron	0.001 ,,	0 ,,
bicarbonate of protoxide of manganese	0.001 ,,	0 ,,
silicate of alumina. . . .	0.021 ,,	0.009 ,,
silica	0.069 ,,	0.058 ,,
	5.508 grains.	7.981 grains.

2. *Gases.*

Carbonic acid	0 324 c.inch.	0.638 c.inch.
sulphuretted hydrogen .	0.051 ,,	0.213 ,,

The springs also contain traces of bromide of sodium, borate of soda, carbonate of lithia, carbonate of baryta, carbonate of strontia, phosphate of lime, carbonate of ammonia, and organic substances.

The mineral springs of Zaizon, in Transylvania, contain, according to Greissing and Schnell, in sixteen ounces of water:—

1. *Solids.*

	Ferdinandsbrunnen.	Franzensbrunnen.
Chloride of sodium	4.69 grains	0.61 grains
iodide of sodium	1.91 ,,	0.06 ,,
carbonate of soda	10.11 ,,	3.16 ,,
carbonate of lime	3.51 ,,	1.56 ,,
carbonate of magnesia . .	0.84 ,,	0.42 ,,
carbonate of protoxide of iron	0.11 ,,	0.58 ,,
sulphate of soda	0.15 ,,	0.35 ,,
silica	0.12 ,,	0.34 ,,
	21.44 grains.	7.08 grains.

2. *Gases.*

Carbonic acid . . . . 19.6 cubic inches.

The amount of iodine said to be contained in the Ferdinandsbrunnen is so completely out of proportion to the quantity of chloride of sodium found in it, that a fresh analysis of that spring appears to be necessary, before we can implicitly adopt it.

The waters of Montecatini, in Tuscany, and those of Lippik, in Sclavonia, deserve special notice on account of their being the only iodated thermals until now known in Europe; it remaining exceedingly doubtful whether the thermals of Dipso and Thermia, in Greece, really contain the large amount of iodine said to exist in them. The Terma Leopoldina, of Montecatini, has been analysed by Signor Giulii, and this analysis which I have reduced from a hundred to sixteen ounces, reads as follows:—

Chloride of sodium . .	168	grains
iodide of potassium . .	0.96	,,
chloride of calcium . .	5.12	,,
chloride of magnesium	4.50	,,
sulphate of soda . . .	2.56	,,
sulphate of magnesia .	5.12	,,
carbonate of lime . . .	3.20	,,
carbonate of magnesia.	0.32	,,
carbonate of iron . . .	0.08	,,
silica	0.24	,,
	190.10	grains.

The temperature of this water is 92°, and it is extensively used in cases of scrofula, gout, and other affections.

The springs of Lippik contain, according to Wagner, in sixteen ounces:—

Carbonate of soda . .	10.285	grains
sulphate of soda . . .	4.790	,,
chloride of sodium . .	4.687	,,
chloride of calcium .	0.788	,,
iodide of calcium . .	0.311	,,
carbonate of magnesia	0.745	,,
carbonate of lime . .	1.125	,,
phosphate of alumina.	0.027	,,
silica	0.834	,,
	23.582	grains.

The gases ascending from the water consist of 28.56 per cent of carbonic acid, and of 71.44 per cent of ni-

trogen. The temperature of this spring is even higher than that of the thermals of Montecatini, viz. 115°; and cases of chronic gout, scrofula, enlargements of the womb and the ovaries, have been beneficially treated by means of the water, which, by the comparatively large amount of sulphate and carbonate of soda, is advantageously distinguished from the other iodo-bromated springs.

IX. EARTHY SPRINGS.

The most important earthy springs are those of Wildungen, Leuk, Lippspringe, Weissenburg, Bath, Lucca, and Pisa. The waters of Wildungen, in the principality of Waldeck, are distinguished from the other Spas of this class by containing a very considerable amount of free carbonic acid, by which their effects are much modified. Their chemical composition is, according to Wiggers, as follows:—

1. *Solids.*

	Stadtbrunnen.	Salzbrunnen.
Bicarbonate of soda . .	0.709 grains	5.457 grains
bicarbonate of protoxide of iron	0.191 ,,	0.236 ,,
bicarbonate of protoxide of manganese	0.073 ,,	0.033 ,,
bicarbonate of lime. . .	5.440 ,,	8.524 ,,
bicarbonate of magnesia	4.055 ,,	8.589 ,,
sulphate of soda	0.919 ,,	0 ,,
chloride of sodium . . .	0.071 ,,	6.284 ,,

sulphate of magnesia . .	0.289 grains	0.455 grains
chloride of magnesium .	0 ,,	0.773 ,,
silica	0.279 ,,	1.116 ,,
alumina	0.008 ,,	0.023 ,,
	12.034 grains.	31.490 grains.
2. *Gases.*		
Carbonic acid	21.802 grains.	23.145 grains.
	or 42.7 c. inch.	or 46 c. inch.

The Wildungen water which is exported in very large quantities, has a special and well-deserved reputation for its curative powers in gravel and lithic diathesis. It is no solvent of renal calculi, nor of stone in the bladder; but it is a capital diuretic, and not only promotes the elimination of gravel and renal calculi, but by its tonic action on the mucous membrane of the urinary passages, serves to prevent the formation of fresh concrements. It is also much used for chronic catarrh of the bladder, neuralgia of the urethra and the neck of the bladder, dysuria and ischuria, and incontinence of the urine.

The Lorenzquelle, of Leuk, according to Brunner, contains in sixteen ounces:—

1. *Solids.*	123°1.
Sulphate of lime	12.712 grains
sulphate of magnesia	1.991 ,,
sulphate of soda	0.509 ,,
sulphate of strontia	0.031 ,,
chloride of sodium	0.055 ,,
chloride of potassium	0.020 ,,

chloride of magnesium	0.027 grains
carbonate of lime	0.357 ,,
carbonate of magnesia	0.002 ,,
carbonate of protoxide of iron	0.024 ,,
silica	0.102 ,,
	15.830 grains.

2. *Gases.*

Carbonic acid	0.267 cub. inch.
oxygen	0.192 ,, ,,
nitrogen	0,347 ,, ,,

The waters of Leuk are mostly employed in atonic ulcers and in chronic diseases of the skin, such as eczema and psoriasis. Bathing is of chief importance in the thermal establishment of that place; and there can be no doubt that very obstinate cases of skin disease, in persons of a torpid constitution, may be improved or even cured by the Leuk treatment, which I have already described (pp. 176 - 178). A modification of that treatment, according to the principles of modern Medicine, is however strongly to be recommended to the Physicians of that Spa The baths are also much used for gouty and rheumatic exudations, and the functional disturbances caused thereby, especially in patients with impaired nutrition and diminished activity of the skin.

The Spas of Lippspringe and Weissenburg are of much repute as remedies for diseases of the respiratory organs. At Lippspringe it is chiefly the nitrogen ascending from the springs, to which the beneficial effects of the treat-

ment are ascribed, while the Physicians of Weissenburg insist upon the lime being the cause of the curative results obtained.

The Arminiusquelle, of Lippspringe, contains, according to Witting, in sixteen ounces:—

1. *Solids.*

Sulphate of lime	4.25 grains
carbonate of lime	5.27 ,,
sulphate of soda.	5.20 ,,
bicarbonate of soda	1.60 ,,
sulphate of magnesia	0.80 ,,
carbonate of magnesia	0.60 ,,
carbonate of protoxide of iron	0.14 ,,
chloride of sodium	0.86 ,,
chloride of magnesium	0.80 ,,
iodides	traces
	19.52 grains.

2. *Gases.*

In a hundred cubic inches are contained:—

carbonic acid .	16.17 cub. inches
nitrogen	4.46 ,, ,,
oxygen	0.55 ,, ,,
	21.12 cub. inches.

The gases which ascend from the spring, consist of

carbonic acid .	83.25 per cent
nitrogen	15.25 ,, ,,
oxygen	1.50 ,, ,,
	100 per cent.

The Ottilienquelle, in the island near Paderborn, contains, according to Brandes, in sixteen ounces:—

1. *Solids.*

Bicarbonate of lime	2.50	grains
sulphate of lime	0.50	,,
chloride of sodium	6.80	,,
bicarbonate of magnesia . . .	0.50	,,
bicarbonate of protoxide of iron	0.05	,,
sulphate of soda	0.75	,,
sulphate of magnesia	0.20	,,
chloride of calcium	0.50	,,
bromides and iodides	traces	
	12.05	grains.

2. *Gases.*

In a hundred cubic inches of water are contained:—

carbonic acid .	2.344	cub. inches
nitrogen. . . .	8.984	,, ,,
oxygen	1.172	,, ,,
	12.500	cub. inches.

The gases ascending from the spring, consist of

carbonic acid .	3	per cent
nitrogen	97	,, ,,

The Hauptquelle of Weissenburg, in the canton of Berne, contains, according to Fellenberg, in sixteen ounces:—

1. *Solids.*

	81°.5.	
Sulphate of lime . . .	17.22	grains
sulphate of magnesia .	5.68	,,

sulphate of strontia . .	0.23	grains
sulphate of soda. . . .	0.61	,,
sulphate of potash . . .	0.29	,,
phosphate of lime . . .	0.15	,,
carbonate of lime . . .	0.86	,,
carbonate of magnesia .	0.65	,,
chloride of sodium. . .	0.11	,,
silica	0.33	,,
	26.13	grains.

2. *Gases.*

Carbonic acid	0.85	cub. inch.

The Lippspringe treatment which consists of the internal use of the Arminiusquelle and the inhalation of the nitrogen ascending from these waters, is chiefly recommended for consumption and for inflammatory irritation of the mucous membrane of the bronchial tubes, connected with great irritability of the system and abdominal plethora. Dr Hörling, of Paderborn, has made a few experiments on the effects of inhalation of nitrogen: he found that the pulse is thereby retarded,—the rate of respiration remains unaltered, but the inspirations become deeper—the temperature of the skin is lowered—the quantity of urinary water and urea diminished—the body-weight is increased—the irritability of the nervous system soothed—the cough lessened—sleep becomes more tranquil—and expectoration is promoted. It seems that inhalations of nitrogen are useful in the incipient stage of consumption, and in young persons with obstinate bron-

chitis. Haemoptoe and cough frequently cease under the influence of this medication, and, according to Dr Fischer, it is even successful in cases where vomicae have been formed. As the observations on the effects of the Lippspringe treatment extend only over a comparatively short period, it will be well to suspend judgment concerning its value for some time to come.

The thermals of Weissenburg, a place, 2758 feet above the sea, situated in a dark and narrow ravine where the rays of the sun only penetrate towards noon, but which has nevertheless a mild climate, and which is not subject to sudden variations of temperature, are also recommended in cases of chronic bronchitis with dry cough and scanty expectoration, more especially in young persons of irritable constitution. In chronic blenorrhoea of the bronchi, no good is to be expected from the use of this Spa. As regards tuberculosis, it seems that in the incipient stage of this disease, when there is considerable irritation and tendency to inflammation, together with bloody expectoration, much improvement may result from the Weissenburg treatment. According to Dr Müller, benefit is obtained from it even in the subsequent stages of the disease, and after hectic fever has already set in. The springs are likewise recommended for hyperaesthesia, hysterical convulsions, and palpitations of the heart with or without structural diseases of that organ.

The Bath water contains, according to Walcker, in an imperial pint:—

1. *Solids.*

Sulphate of lime	10.20	grains
sulphate of soda	2.42	,,
chloride of magnesium .	1.67	,,
chloride of sodium. . .	1.89	,,
carbonate of lime . . .	1.33	,,
alumina	0.01	,,
silica	0.41	,,
oxide of iron	0.03	,,
	17.96	grains.

2. *Gases.*

Carbonic acid	0.20	cub. inch.

This Spa has proved useful in certain diseases of the skin, scrofula, paralysis from weakness, atony of the stomach and intestines, coxarthrocace, gout, and other diseases.

The Bagni di S. Giuliano, near Pisa, contain, according to Signor Giulii, in sixteen ounces:—

1. *Solids.*

Carbonate of lime . . .	10.24	grains
chloride of sodium . . .	4.48	,,
chloride of magnesium .	0.64	,,
sulphate of soda	3.20	,,
carbonate of soda . . .	0.16	,,
carbonate of magnesia .	1.28	,,
sulphate of magnesia. .	traces	
	20.02	grains.

2. *Gases.*

Carbonic acid	0.528	cub. inch.

The temperature of these springs is 117°.3, and they are much employed in certain diseases of the urinary organs, and in gout and rheumatism.

The thermal springs of Lucca, which have a temperature of 116°, contain, according to Giulii, in sixteen ounces:—

Sulphate of lime . . .	5.82	grains
carbonate of lime . . .	0.39	,,
carbonate of magnesia .	0.06	,,
chloride of sodium . . .	1.28	,,
chloride of magnesium .	0.32	,,
alumina	0.32	,,
sulphate of magnesia .	1.18	,,
	9.37	grains.

These waters act chiefly by their high temperature and are of value in atonic gout, chronic rheumatism, certain forms of paralysis, and diseases of the skin.

X. INDIFFERENT THERMAL SPRINGS.

The most striking effects of these Spas are, to stimulate the skin and to stir up the nervous system. They are therefore especially used in chronic rheumatism and atonic gout; in diseases of the skin, such as prurigo, psoriasis, lichen; in neuralgia and paralysis due to rheumatic and gouty exudations, to parturition, or to severe diseases, such as typhoid fever and diphtheria; in hysteria; and in general weakness and marasmus.

One of the most celebrated Spas of this class is Gastein, where eight thermal springs are used for therapeutical purposes. Their chemical composition is quite identical, and they merely differ in their temperature, which varies between 95° and 118°. In sixteen ounces of this water, Wolf has found the following ingredients:—

1. *Solids.*

Sulphate of soda	1.51 grains
chloride of sodium	0.36 ,,
carbonate of lime	0.36 ,,
silica	0.24 ,,
carbonate of soda	0.04 ,,
phosphate of alumina	0.04 ,,
carbonate of protoxide of iron . . .	0.05 ,,
carbonate of protoxide of manganese	0.02 ,,
sulphate of potash	0.01 ,,
carbonate of magnesia	0.02 ,,
fluoride of calcium	traces
strontia	traces
organic matter	traces
	2.68 grains.

2. *Gases.*

In a hundred parts of gas are contained:—

nitrogen	69.112
oxygen	30.888.

Gastein is mostly resorted to by decrepit, old, and paralytic persons, who are, by the use of the baths, often restored to comparative health and vigour. The

average duration of the baths is from a quarter of an hour to an hour, and even more; and that of the treatment from four to six weeks.

The waters of Teplitz, in Bohemia, are of great therapeutical value in those forms of paralysis and neuralgia, in which there are no such structural diseases as would preclude the possibility of a cure. Besides the thermal baths, the douche, moor-baths, and moor-cataplasms, are used there. The Hauptquelle, of Teplitz, which has a temperature of 120°, contains, according to Wolf, in sixteen ounces:—

1. *Solids.*

Sulphate of potash	0.098	grains
sulphate of soda	0.290	,,
carbonate of soda	2.635	,,
phosphate of soda	0.014	,,
fluoride of silicium	0.351	,,
chloride of sodium	0.433	,,
carbonate of lime	0.330	,,
carbonate of strontia	0.027	,,
carbonate of magnesia	0.088	,,
carbonate of protoxide of iron . . .	0.019	,,
carbonate of protoxide of manganese	0.021	,,
phosphate of alumina	0.020	,,
silica	0.443	,,
crenic acid	0.034	,,
	4.854	grains.

2. *Gases.*

100 parts of the gas contain:—

nitrogen	94.59
carbonic acid	4.74
oxygen	0.66.

The thermal springs of Wildbad, in Würtemberg, contain, in sixteen ounces:—

1. *Solids.*

Chloride of sodium . . .	1.82 grains
carbonate of soda	0.53 ,,
sulphate of soda	0.40 ,,
sulphate of potash	0.20 ,,
carbonate of lime	0.34 ,,
carbonate of magnesia . .	0.70 ,,
carbonate of protoxide of iron and manganese . .	0.20 ,,
silica	0.39 ,,
	3.58 grains.

2. *Gases.*

In 100 parts of gas are contained:—

nitrogen. . . .	79.25	91.56
oxygen	8.25	6.44
carbonic acid .	12.50	2.00.

The baths, which are chiefly taken in piscines, prove most beneficial in the several forms of rheumatism and morbid affections consequent upon it, even when of a severe kind, and of long standing.

The springs of Warmbrunn, in Silesia, contain, according to Fischer, in sixteen ounces:—

1. *Solids.*

	97° to 104°.
Sulphate of soda	1.72 grains
carbonate of soda	0.81 ,,
chloride of sodium . . .	0.55 ,,
chloride of calcium . . .	0.05 ,,
carbonate of lime	0.16 ,,
carbonate of magnesia / phosphate of alumina } .	0.06 ,,
extractive matter	0.17 ,,
silica	0.55 ,,
	4.07 grains.

2. *Gases.*

Nitrogen	0.017 cub. inch.
carbonic acid	0.025 ,, ,,

Their temperature ranges between 95° and 105°, and they are applicable in the same class of cases, in which the other indifferent thermals are used.

The thermal springs of Pfäffers and Ragatz contain, according to Capeller, in sixteen ounces:—

Chloride of sodium . . .	0.21 grains
sulphate of soda.	0.62 ,,
sulphate of lime.	0.37 ,,
carbonate of magnesia . .	0.87 ,,
carbonate of lime	0.32 ,,
chloride of magnesium and extractive matter . . .	0.16 ,,
resinous matter	0.06 ,,
	2.61 grains.

These waters are used not only for bathing, but also for drinking, the usual dose being from four to eight tumblersful. The climate and neighbourhood of Pfäffers are so wild and gloomy, that patients who require more exhilarating and genial surroundings, had better not be sent to that Spa. In this respect, Ragatz is more pleasant, but as a large number of tourists are continually on the move at this latter place, it is not suited for patients to whom quiet is necessary.

The Römerbad, of Tüffer, in Styria, contains, according to M. Hruschauer, in sixteen ounces:—

1. *Solids.*	
Sulphate of soda	0.157 grains
chloride of magnesium	0.224 ,,
chloride of sodium	0.331 ,,
sulphate of lime	0.078 ,,
carbonate of lime	0.187 ,,
carbonate of magnesia	0.043 ,,
carbonate of protoxide of iron	traces
silica	0.499 ,,
	1.519 grains.
2. *Gases.*	
Carbonic acid	2.239 grains.

This spring is much employed in all forms of chronic rheumatism and in certain diseases of women, especially in chronic metritis, with consequent amenorrhoea, dysmenorrhoea, and catarrh of the cervix uteri; in neuralgia of the ovaries, exudations after

perimetritis and similar complaints. Exudations are absorbed, and the paralysis caused by them is at the same time cured. The climate, air, and neighbourhood of Tüffer are very genial.

The water of the "hot-wells" of Clifton contains in sixteen ounces:—

Carbonate of lime . .	1.777	grains
chloride of sodium . .	0.589	,,
sulphate of lime . . .	0.987	,,
sulphate of soda . . .	0.302	,,
sulphate of magnesia .	0.129	,,
nitrate of magnesia .	0.291	,,
carbonate of magnesia	0.066	,,
carbonate of iron . .	0.010	,,
silica	0.127	,,
	4.421	grains.

Clifton has been much used in a variety of diseases, such as acidity of the stomach, diabetes, gravel, bronchitis, chronic diarrhoea &c., for which however many other Spas are better suited. The temperature of the water being rather low, when compared with that of other indifferent thermals, Clifton would seem to be suitable specially for the milder forms of those diseases in which Teplitz, Wildbad, and Gastein are employed.

The same may be said of the Buxton water, in sixteen ounces of which Professor Lyon Playfair found:—

1. *Solids.*

Carbonate of lime	0.777 grains
carbonate of magnesia .	0.454 ,,
chloride of potassium . .	0.250 ,,
chloride of sodium	0.242 ,,
chloride of magnesium . .	0.112 ,,
silica	0.167 ,,
oxide of iron and alumina	0.024 ,,
sulphate of lime	0.232 ,,
fluoride of calcium	traces
phosphate of lime	traces
	2.058 grains.

2. *Gases.*

Carbonic acid	0.740 grains.
nitrogen	80 cub. inches.

The temperature of this water is 82°.

The following is the composition of the indifferent thermal springs of Plombières, according to M. Lheritier, whose analysis I have reduced from a thousand grammes to sixteen ounces:—

	Bain des Dames.	Bain Romain.
	grains.	grains.
Silicate of soda	0.6257	0.5278
silicate of potash	0.0080	0
silicate of lime and magnesia .	0.1530	0.3052
chloride of sodium, chloride of potassium, chloride of calcium . . .	0.2754	0. 229

	Bain des Dames.	Bain Romain.
	grains.	grains.
sulphate of soda	0.6273	0.3901
arseniate of soda	0.0053	0
silica	0.0887	0.3213
alumina	0.0760	0.1980
nitrogenous organic matter . .	0.1530	0
	2.0069	1.6759

The internal use of this water is chiefly recommended for catarrh of the stomach and intestines, and seems to be most efficacious where there is any irritation of these organs. The baths are employed in all cases in which Teplitz and other indifferent thermals prove beneficial.

The springs of Landeck have, according to Fischer, the following chemical composition:—

1. *Solids.*

	Wiesenquelle.	Georgenbrunnen.
	81°.5.	83°.75.
Sulphate of soda . . .	0.542 grains	0.248 grains
bicarbonate of soda . .	0.545 ,,	0 ,,
chloride of potassium . .	0 ,,	0.165 ,,
chloride of sodium . .	0.005 ,,	0 ,,
chloride of calcium . .	0.064 ,,	0 ,,
crenate of soda	0 ,,	0.286 ,,
sulphate of lime	0 ,,	0.008 ,,
carbonate of lime . . .	0.075 ,,	0.081 ,,
carbonate of magnesia .	0.005 ,,	0.009 ,,

	Wiesenquelle. 81°.5.	Georgenbrunnen. 83°.75.
phosphate of alumina, iron and manganese .	0 grains	0.012 grains
silica	0.327 ,,	0.271 ,,
	1.563 grains.	1.122 grains.
2. *Gases.*		
Sulphuretted hydrogen.	0.015 c. inch.	traces
carbonic acid	0.172 ,,	0.26 c. inch.
nitrogen	0 ,,	0.62 ,,

Landeck is, by its low temperature, decidedly inferior to Gastein, Warmbrunn, and Wildbad, and more similar to Buxton and Clifton. Besides the baths, inhalation of the gases ascending from the water, whey, moor-baths and moor-cataplasms, are also used there.

The numerous thermal springs of Schlangenbad, in Nassau, do not differ from each other in their chemical composition. They contain, according to Fresenius, in sixteen ounces:—

1. *Solids.*	
Sulphate of potash . .	0.091 grains
chloride of potassium.	0.004 ,,
chloride of sodium . .	1.825 ,,
phosphate of soda . .	0.004 ,,
carbonate of soda . .	0.079 ,,
carbonate of lime . .	0.250 ,,
carbonate of magnesia	0.047 ,,
silica	0.258 ,,
	2.558 grains.

2. *Gases.*

Carbonic acid . . . . 0.668 grains.

This water is only used for bathing, and often affords relief in cases of irritability of the nervous system, especially if due to, and connected with, disturbances of the menstrual function, neuralgic dysmenorrhoea, &c. Whey is internally administered, and contributes to invigorate the system generally.

XI. CHALYBEATES.

a. ACIDULOUS CHALYBEATES.

The most powerful chalybeates are those in which, with the exception of iron, only a small amount of solid ingredients, and much carbonic acid is contained. The quantity of iron found in the true chalybeates, varies from 0.25 to 0.8 grains. True acidulous chalybeates are most admirable remedies for anaemia, and all morbid conditions consequent upon it, such as certain forms of indigestion, constipation and diarrhoea, amenorrhoea, dysmenorrhoea, blenorrhoea of the uterus and the vagina, sterility, and tendency to abortion. In certain diseases of the nervous system, in head-ache, neuralgia in the back, chorea, tremor, paralysis, hysteria, and hypochondriasis, the Spas of this class also prove highly beneficial.

The acidulous chalybeates which enjoy the greatest reputation for their curative powers, are the waters of

Schwalbach, in Nassau, Spaa, in Belgium, and Pyrmont, in the principality of Waldeck. At Schwalbach ten springs rise from clay-slate; four of which are medically used, viz. the Stahlbrunnen, Weinbrunnen, Paulinenbrunnen, and Rosenbrunnen. Of these, the two first are the most important and have, according to Fresenius, the following chemical composition:—

1. *Solids.*

	Stahlbrunnen. 46°.3—51°.1. grains.	Weinbrunnen. 49°.3—50°. grains.
Bicarbonate of protoxide of iron	0.643	0.443
bicarbonate of protoxide of manganese	0.141	0.070
bicarbonate of soda . . .	0.158	1.884
chloride of sodium	0.052	0.066
sulphate of soda	0.061	0.048
sulphate of potash	0.029	0.057
bicarbonate of lime . . .	1.700	4.394
bicarbonate of magnesia .	1.630	4.467
silica	0.246	0.357
phosphate of soda . . . / borate of soda . . . . / organic matter	traces	traces
	4.660	11.968

2. *Gases.*

	Stahlbrunnen.	Weinbrunnen.
Free carbonic acid .	50.27 cubic inches.	45.6 c. i.
sulphuretted hydrogen	0.003 „ „	0.003 „

The forms of anaemia for which Schwalbach proves

most efficacious, are those caused by impaired nutrition, loss of blood, chlorosis and anaemia consequent upon long-continued ague. Respecting leucorrhoea, Dr Frickhoefer has found that only those forms of it which are due to anaemia and chlorosis, may be cured by the Schwalbach water, provided the sensibility of the mucous membrane is not too high, in which case the affection would be probably aggravated. The bathing establishment of Schwalbach is very good, and carbonic acid baths are taken simultaneously with the internal use of the water.

At Spaa, seven springs are employed which are only slightly different in their chemical composition. These are the Pouhon, Sauvenière, Groesbeck, Geronstère, Tonnelet No. 1 and No. 2, and Barisart. The quantity of iron contained in these waters varies from 0.24 grains (Groesbeck) to 0.45 (Geronstère). The Pouhon which is generally drunk, contains in sixteen ounces, according to Struve:—

1. *Solids.*

Carbonate of protoxide of iron . .	0.375	grains
carbonate of protoxide of manganese	0.052	„
carbonate of soda	0.738	„
carbonate of lime	0.986	„
carbonate of magnesia	1.123	„
sulphate of potash	0.079	„
sulphate of soda	0.038	„
chloride of sodium	0.450	„
phosphate of lime	5.014	„

phosphate of alumina	0.009 grains
silica	0.499 „
	4.3593 grains.

2. *Gases.*

Carbonic acid*	21.6 cub. inches.

The Spaa water is chiefly distinguished from Schwalbach by its containing a lesser amount of carbonic acid, whereby it is, for certain cases, rendered inferior to the latter. There is no good bathing establishment there at present, and real carbonic acid baths are not yet to be had. We hope that this deficiency may soon be filled up.

At Pyrmont, there are six acidulous chalybeates and three muriated springs which are therapeutically employed. The Pyrmont waters are in so far inferior to those of Schwalbach, as they contain, besides the iron, a considerable quantity of sulphate and carbonate of lime, so that, while the total amount of solids in the Schwalbach Stahlbrunnen is only 3.28 grains, and in the Pouhon only 4.35, it is in the Trinkbrunnen, of Pyrmont, not less than 22.285. The muriated springs, which contain from 35 to 95 grains of solids, amongst which chloride of sodium predominates, considerably add to the curative resources of Pyrmont, which is thus not only useful in all forms of anaemia, but also in chronic catarrh of the respiratory organs, and in

* According to Struve, the Pouhon contains only 8.19 cubic inches of carbonic acid; this is evidently a mistake, and I have therefore substituted for it the number found by Monheim.

scrofula, especially when associated with anaemia. The chalybeates of Pyrmont have, according to Professor Wiggers, the following chemical composition:—

1. *Solids.*

	Trinkbrunnen. 54°.5. grains.	Neubrunnen. 51°.1. grains.
Bicarbonate of protoxide of iron	0.577	0.457
bicarbonate of protoxide of manganese	0.045	1.013
bicarbonate of lime	10.477	12.374
sulphate of lime	9.054	0.474
bicarbonate of magnesia . . .	0.172	0.215
bicarbonate of ammonia . . .	0.003	traces
sulphate of potash	0.233	0.499
sulphate of soda	0	2.219
sulphate of magnesia	3.889	2.951
chloride of sodium	0.515	8.908
chloride of lithium	0.026	0.014
chloride of magnesium . . .	0.696	0
nitrate of soda	0.0005	0.0006
silica	0.026	0.287
alumina	0.011	0.133
organic matter and arsenious acid	traces	traces
	28.929	29.550

2. *Gases.*

Free carbonic acid	15.408	13.662

The springs of Driburg, in Westphalia, contain a large amount of iron, together with carbonate and sul-

phate of lime, and carbonic acid. Besides the internal use of the springs, moor-baths and carbonic acid baths of a very excellent description, are extensively administered there. Anaemia associated with disturbances of the abdominal circulation, anomalies of menstruation, hysteria, and loss of motor power, are the diseases chiefly suitable for the Driburg treatment. Dr Brück, of Driburg, has recorded the case of an English lady who had, after severe mental afflictions, contracted the habit of opium-eating, and who was accustomed to take twenty grains of the acetate of morphia in the course of twenty-four hours. While at Driburg, she daily drank about a hundred ounces or even more of the water, with great benefit to her general health; nor did she then find it necessary to indulge in opium; but the year after, in consequence of new family troubles, she again took to morphia, and that time the use of the waters did not prove so good a substitute as before.

The Trinkquelle, of this place, has, according to M. Wiggers, the following chemical composition:—

1. *Solids.*

Bicarbonate of protoxide of iron . . .	0.7862	grains
bicarbonate of protoxide of manganese	0.1094	„
bicarbonate of lime	14.8911	„
sulphate of lime	10.1571	„
bicarbonate of magnesia	0.5305	„
sulphate of potash	0.0822	„
sulphate of soda	7.9688	„
sulphate of magnesia	4.7810	„

nitrate of soda	0.0048	grains
chloride of sodium	0.6982	„
chloride of lithium	0.0189	„
silica	0.0234	„
alumina	0.0019	„
arsenious acid	0.0002	„
	40.1177	grains.

2. *Gases.*

Free carbonic acid	17.1343	„
sulphuretted hydrogen	0.0004	grains.

It is doubtful whether the very small amount of arsenious acid found in this water, has any therapeutical power, especially as by the escape of carbonic acid, hydrated peroxide of iron is formed, by which arsenic is rendered insoluble.

The "Stahlquelle", of Brückenau, near Kissingen, has, according to Scherer, the following chemical composition:—

1. *Solids.*

Bicarbonate of protoxide of iron	0.093	grains
bicarbonate of protoxide of manganese	0.039	„
sulphate of potash	0.146	„
sulphate of soda	0.082	„
sulphate of magnesia	0.470	„
chloride of magnesium	0.084	„
bicarbonate of magnesia	0.159	„
bicarbonate of lime	1.749	„
phosphate of lime	0.004	„

silica	0.106 grains
extractive matter and crenates . . .	0.488 „
	3.409 grains.

2. *Gases.*

Carbonic acid	38.1 c. inch.

It will be seen from the above analysis that the quantity of iron contained in this spring is very small, and its therapeutical effects are no doubt chiefly due to the water and the carbonic acid. Brückenau is often used by patients who have previously gone through a course of the Kissingen waters; it affords relief in the milder forms of anaemia, anomalies of menstruation, and in persons suffering from general weakness.

The "Fürstenquelle", of Imnau, in Hohenzollern, contains, according to Siegwart, in sixteen ounces:—

1. *Solids.*

Carbonate of protoxide of iron	0.500 grains
chloride of sodium	1.004 „
chloride of magnesium . . .	0.326 „
sulphate of magnesia	0.335 „
carbonate of magnesia . . .	1.089 „
carbonate of lime.	6.855 „
sulphate of lime	0.221 „
silica	1.029 „
organic matter	1.120 „
	11.519 grains.

2. *Gases.*

Carbonic acid	30.351 cub. inches.

There are five other springs at this place, two of which contain even a larger amount of iron than the Fürstenquelle, viz. 0.640 and 0.639 grains in sixteen ounces, and are also very rich in carbonic acid; two others contain a much smaller quantity of iron, viz. 0.087 and 0.086, and a fifth none at all, but much carbonic acid, so that the Physician has a variety of remedies at hand to suit the different constitutions of the patients. The water is generally mixed with milk or whey before being drunk. At Carlsthal, close to Imnau, there is a bitter-water, which has only quite recently been analysed, but which will no doubt prove useful in all cases in which the waters of Friedrichshall, Kissingen, Purton, and others may be employed.

The springs of Altwasser, in Silesia, contain, according to Fischer, in sixteen ounces:—

1. *Solids.*

	Georgenbrunnen. 70°. grains.	Oberbrunnen. 70°. grains.
Carbonate of protoxide of iron	0.37	0.306
carbonate of protoxide of manganese	0	0.130
chloride of potassium	0.09	0.09
sulphate of potash	0	0.086
sulphate of soda	0.89	0.40
sulphate of magnesia	0	0.250
carbonate of magnesia	0.72	0.308
carbonate of lime	2.88	0.860

	Georgenbrunnen. 70°. grains.	Oberbrunnen. 70°. grains.
sulphate of lime.	0	0.100
carbonate of soda	1.21	0
silica	0.08	0.520
	6.54	3.180

2. *Gases.*

Carbonic acid . 106 volumes in 100 vols., 50 vols. in 100 vols. of water.

This analysis which was made in 1830, is of doubtful value, and it seems as if great alterations had since then taken place in these waters, so that we must wait for a fresh analysis, before we are justified in recommending them.

The Cambray Chalybeate spring contains, according to Mssrs Abel and Rowney, in an imperial gallon (70000 grains):—

1. *Solids.*

Carbonate of protoxide of iron	2.8938	grains
carbonate of lime	25.1209	„
chloride of potassium	5.0491	„
carbonate of soda	4.1867	„
carbonate of magnesia	4.3624	„
sulphate of potash	0.4781	„
phosphate of lime	0.5579	„
silicic acid	0.6678	„
apocrenic acid	0.1470	„

crenic acid	0.2429 „
organic extractive matter . .	0.0098 „
	44.9302 grains.

2. *Gases.*

Free carbonic acid	19.919 cub. inch.

The quantity of carbonic acid contained in this water being very small, it is rather heavy and indigestible, and for this reason greatly inferior to the true acidulous chalybeates.

The springs of St. Moritz, in Upper Engadin, 5910 feet above the sea, can, on account of the roughness of the climate, only be used in July and August. They contain 0.182 to 0.252 grains of carbonate of iron, 2.578 to 6.843 grains of carbonate of lime, and 39.6 to 40.6 cubic inches of carbonic acid. They are therefore suitable for most affections in which Spaa, Schwalbach, and Driburg are employed.

b. SALINE ACIDULOUS CHALYBEATES.

By this name we comprehend those Spas, which besides carbonate of iron and carbonic acid, also contain a certain quantity of carbonate and sulphate of soda, and chloride of sodium. They act beneficially in most diseases in which the alkaline acidulous waters, the alkaline saline waters, and the muriated waters are employed, especially if a certain degree of anaemia is associated with those complaints. In many cases it is difficult to decide whether a true acidulous chalybeate

or a saline acidulous chalybeate should be prescribed; but it may be laid down as a general rule that in pure anaemia the former, and in anaemia complicated with abdominal disturbances, the latter are preferable.

The most important Spa of this group is Franzensbad, in Bohemia, where several saline chalybeates of unrivalled composition rise from mica-slate. Three of them are used for drinking, one for bathing, and one for carbonic acid gas-baths. The iron mineral-moor which is employed for cataplasms and baths, forms a valuable part of the curative resources of Franzensbad.

The springs of this place are not identical in their composition. They all contain iron, the most considerable quantity of which is found in the Wiesenquelle, while the Salzquelle contains only little of it and is chiefly rich in carbonic acid, sulphate of soda, bicarbonate of soda and chloride of sodium.

1. *Solids.*

	Wiesenquelle, according to Wolff. 51°. grains.	Salzquelle, according to Tromsdorff. 52°.6. grains.
carbonate of protoxide of iron	0.376	0.016
carbonate of protoxide of manganese . . .	0.093	0.004
sulphate of soda . .	25.223	17.933
sulphate of potash .	0.1362	0
phosphate of soda .	0.062	0
chloride of sodium .	9.346	9.216

	Wiesenquelle, according to Wolff.	Salzquelle, according to Tromsdorff.
	51°.	52°.6.
	grains.	grains.
bromide and iodide of sodium	traces	0
carbonate of magnesia	1.190	0.132
carbonate of lithia .	0.063	0
carbonate of lime .	1.291	1.607
carbonate of strontia	0.049	0.003
phosphate of lime and alumina	0.007	0.004
silica	0.056	0.333
	45.108	38.568

2. *Gases.*

Carbonic acid . . .	45.107 cub. inch.	26.89 c. inch.

There are three other springs at Franzensbad, the Kalte Sprudel, the Franzensquelle, and the Louisenquelle, which latter is used for bathing only. They contain, according to Tromsdorff and Berzelius, in sixteen ounces:—

1. *Solids.*

	Franzensquelle.	Kalte Sprudel.	Louisenquelle.
	52°.9.	51°.	53°.9.
	grains.	grains.	grains.
Carbonate of protoxide of iron	0.23	0.200	0.328

	Franzensquelle.	Kalte Sprudel.	Louisenquelle.
	52°.9.	51°.	53°.9.
	grains.	grains.	grains.
carbonate of protoxide of manganese . . .	0.04	0.004	0
chloride of sodium . .	9.23	8.600	6.766
sulphate of soda . . .	24.50	26.930	21.416
carbonate of soda . .	5.17	7.173	5.498
carbonate of lime . . .	1.82	1.600	1.600
carbonate of strontia .	0.003	0.001	0
carbonate of magnesia.	0.67	0.013	0
carbonate of lithia . .	0.03	0	0
phosphate of lime and magnesia	0.032	0.028	0
silica	0.47	0.056	0.228
	42.18	44.606	35.836
2. *Gases.*			
Carbonic acid	40.84 c.i.	39.4 c. i.	32.53 c. i.

The moor of Franzensbad is remarkable for the large quantity of iron it contains. Its composition is as follows:—

1. *Substances soluble in water.*

Sulphuric acid . . .	128.477	grains
potash	0.106	„
soda	5.002	„
lithia and ammonia .	traces	
magnesia	0.415	„
lime	11.075	„

alumina	2.378	grains
protoxide of iron . .	46.317	„
protoxide of manganese	0.268	„
silica	0.589	„
crenic acid	28.186	„
humus	49.441	„
loss	0.186	„
	252.439	grains.

2. *Substances soluble in nitric and hydrochloric acid.*

Soda	7.135	grains
magnesia	1.374	„
alumina	2.848	„
lime	1.224	„
strontia	0.396	„
iron	16.213	„
sulphur	16.463	„
silica	2.304	„
phosphoric acid . . .	0.875	„
	48.831	grains.
3. *Humic acid*	421.057	„
4. *Wax*	18.417	„
5. *Moor-resin*	25.500	„
6. *Other ingredients* . . .	79.735	„
7. *Vegetable remains* . . .	153.729	„
loss	0.292	„
	1000.000	grains.

The amount of sulphuric acid contained in this moor is so considerable that it is more than sufficient for neutralising the bases, and it therefore forms bisulphates.

It is at present not settled whether the therapeutical effects of the moor are due to absorption of some of its constituents or to its mere contact with the skin; but that the moor-baths have a most invigorating influence upon the system, is proved beyond doubt. The Franzensbad treatment is highly successful in all forms of anaemia, and in abdominal plethora and its consequences, if the patients are at the same time in an anaemic condition. Amongst the different forms of anaemia, chlorosis is most rapidly cured at Franzensbad. The moor-baths are mostly used in certain forms of paralysis, rheumatism and gout. This Spa is also much to be recommended for patients who have previously used Marienbad, or other alkaline waters, and have been somewhat lowered by them.

The springs of Cudova, in the county of Glatz, contain, according to Duflos, in sixteen ounces:—

1. *Solids.*

	Trinkquelle. 52°.2.	Oberbrunnen. 52°.2.
Carbonate of protoxide of iron	0.197 grains	0.151 grains
arseniate of protoxide of iron	0.012 „	0.008 „
carbonate of protoxide of manganese . . .	0.021 „	0.016 „
bicarbonate of soda .	9.409 „	7.300 „
sulphate of soda . . .	5.425 „	4.187 „
chloride of sodium .	0.900 „	0.702 „

	Trinkquelle 52°.2.		Oberbrunnen. 52°.2.	
chloride of potassium	0.034	grains	0.025	grains
carbonate of lime . .	3.763	„	2.950	„
phosphate of lime . .	0.051	„	0.032	„
carbonate of magnesia	1.200	„	0.947	„
silica	0.704	„	0.610	„
	21.720	grains.	16.928	grains.

2. *Gases.*

Carbonic acid . . .	33.25 c. inch.	33.25 c. inch.

These springs are much employed for anomalies of menstruation and hysteria. It is probable that the arsenic contained in the Cudowa water contributes in some measure to the curative results obtained, and it might on this account be recommended for obstinate diseases of the skin, and more especially for proriasis.

The springs of Petersthal, in the grandduchy of Baden, contain, according to Professor Bunsen, in sixteen ounces:—

1. *Solids.*

	Stahlquelle. 50°.3.		Salzquelle. 47°.9.	
Bicarbonate of protoxide of iron	0.354	grains	0.346	grains
bicarbonate of lime . .	11.713	„	11.580	„
bicarbonate of magnesia	3.501	„	4.485	„
bicarbonate of lithia . .	0.046	„	0.022	„
bicarbonate of soda . .	0.461	„	0.281	„
chloride of sodium . .	0.303	„	0.350	„
sulphate of soda	6.069	„	6.547	„

	Stahlquelle. 50°.4.	Salzquelle. 47°.9.
sulphate of potash . . .	0.573 grains	0.603 grains
phosphate of alumina .	0.055 „	0.027 „
silica	0.094 „	0.680 „
organic substances, protoxide of manganese, arsenious acid	traces	traces
	23.769 grains.	24.921 grains.

2. *Gases.*

Carbonic acid	33.2 cub. inch.	34.2 cub. inch.
nitrogen	0 „ „	0.02 „ „

These waters are suitable for the milder forms of anaemia, and the nervous disturbances connected with it.

The springs of Elster, in Saxony, have, according to Stein, the following composition:—

1. *Solids.*

	Trinkquelle. 50°.	Albertsbrunnen. 50°.
Carbonate of protoxide of iron	0.350 grains	0.324 grains
carbonate of protoxide of manganese . . .	0.084 „	traces
carbonate of soda . .	3.945 „	4.704 „
chloride of sodium . .	14.380 „	8.150 „
chloride of potassium .	0.114 „	0.288 „
carbonate of lime . .	1.098 „	0.809 „

	Trinkquelle. 50°.	Albertsbrunnen. 50°.
carbonate of magnesia	1.217 grains	0.773 grains
silica	0.338 „	0.249 „
	44.199 grains.	39.535 grains.

2. *Gases.*

Carbonic acid . . .	28.4 cub. inch.	16.6 cub. inch.
nitrogen	0.037 „	0.092 „
oxygen	0.006 „	0.008 „

The Salzquelle, of this place, has nearly the same chemical composition, with the exception that it contains 48.851 grains of sulphate of soda, so that it may be advantageously used by erethic persons, for whom the other springs would prove too exciting. Thus, while the Trinkquelle and the Albertsbrunnen resemble the springs of Franzensbad, the Salzquelle is rather similar to the springs of Marienbad, and may be taken for the same diseases in which the Kreuzbrunnen acts beneficially.

The chalybeate spring of Bocklet, near Kissingen, contains, according to Kastner, in sixteen ounces:—

1. *Solids.*

Carbonate of protoxide of iron	0.6107 grains
carbonate of protoxide of manganese	0.0010 „
carbonate of magnesia	3.3600 „
carbonate of lime	6.5450 „
bromide of magnesium	0.0002 „
chloride of magnesium	4.4320 „

chloride of potassium	0.1473	grains
chloride of sodium	6.5522	„
sulphate of soda	2.5421	„
sulphate of magnesia	3.2300	„
silica	0.2210	„
alumina	0.0023	„
extractive matter	0.0201	„
	28.6639	grains.

2. *Gases.*

Carbonic acid . . . . 39.388 cub. inches.

The earthy chalybeate of Recoaro, in Venetia, contains, according to Cenedella:—

1. *Solids.*

Carbonate of protoxide of iron	0.23	grains
carbonate of lime	5.15	„
carbonate of magnesia . . .	0.47	„
carbonate of soda	0	„
sulphate of magnesia	5.00	„
sulphate of soda	0.23	„
sulphate of lime	9.50	„
chloride of magnesium . . .	0.023	„
silica	0.319	„
	20.78	grains.

2. *Gases.*

Carbonic acid . . . . . . 17.99 cub. inches.

The waters of Recoaro are employed in the milder forms of abdominal plethora, in cachexy due to intermittent fever, and certain diseases of the urinary organs, especially catarrh of the bladder.

The springs of Reinerz, in Silesia, contain in 16 ounces, according to Duflos:—

1. *Solids.*

	Laue Quelle. 62°.8.	Nerikenquelle. 54°.
Carbonate of protoxide of iron	0.290 grains	0.137 grains
carbonate of protoxide of manganese . . .	0.023 „	0.007 „
carbonate of soda . .	4.266 „	2.089 „
chloride of sodium . .	0.120 „	0 „
chloride of potassium	0 „	0.065 „
sulphate of potash . .	0.650 „	0.481 „
carbonate of lime . .	6.298 „	3.168 „
carbonate of magnesia	1.797 „	0.730 „
silica	0.499 „	0.653 „
arseniate of protoxide of iron	traces	0 „
phosphate of iron and lime	traces	0 „
	13.944 grains.	7.329 grains.

2. *Gases.*

Carbonic acid . . .	35.5 cub. inch.	32 cub. inch.

These waters are used with advantage for bronchitis in anaemic persons, and for general irritability connected with anaemia.

The springs of Rippoldsau, in the grandduchy of Baden, contain according to Professor Bunsen, in sixteen ounces:—

1. *Solids.*

	Josephsquelle. 46°.4.		Leopoldsquelle. 49°.5.	
Bicarbonate of protoxide of iron	0.395	grains	0.455	grains
bicarbonate of protoxide of manganese . . .	0.033	„	0.078	„
bicarbonate of lime . .	12.939	„	14.953	„
bicarbonate of magnesia	0.543	„	2.888	„
sulphate of soda . . .	9.316	„	6.769	„
sulphate of potash . .	0.465	„	0.271	„
sulphate of lime . . .	0.428	„	0.134	„
sulphate of magnesia .	1.866	„	0.150	„
phosphate of lime . . .	0	„	0.136	„
chloride of magnesium	0.650	„	0.336	„
alumina	0.034	„	0.020	„
silica	0.439	„	0.663	„
phosphoric acid, arsenic, and organic matter .	traces		traces	
	26.908	grains.	26.853	grains.

2. *Gases.*

Free carbonic acid . .	14.936	c. inch.	15.985	c. inch.
nitrogen	0.003	„	0.0003	„
oxygen	0	„	0.003	„

The Harrowgate muriated chalybeate waters have been analysed by Dr Hofmann. Reduced from one gallon to sixteen ounces, the analysis is as follows:—

1. *Solids.*

	Montpellier Saline Chalybeate.		Cheltenham Saline Chalybeate.	
Carbonate of protoxide of iron	0.279	grains	0.463	grains
carbonate of protoxide of manganese . . .	traces		traces	
chloride of sodium . .	65.684	„	15.884	„
chloride of potassium	1.138	„	2.741	„
chloride of calcium .	15.928	„	5.163	„
chloride of magnesium	3.564	„	3.403	„
carbonate of magnesia	4.180	„	0	„
bromide of sodium .	traces		traces	
iodide of sodium . .	traces		traces	
ammonia	traces		traces	
silica	0.095	„	0.145	„
organic matter . . .	trace		0.028	„
	90.867	grains.	28.587	grains.

2. *Gases.*

Carbonic acid	2.417	c. inch.	1.950	c. inch.
carburetted hydrogen	0.240	„	0.500	„
oxygen	0.051	„	0	„
nitrogen	0.648	„	0.101	„

These waters would no doubt be valuable in many complaints, were it not that the quantity of carbonic acid found in them is so small that they are unpalatable and difficult of digestion.

The springs of Borszék, ten miles from Hermannstadt, in Transylvania, and close to the Moldavian frontier, deserve more notice than they have

hitherto attracted. There are ten springs at that place, of which however only two are used for medical purposes. These are the Haupttrinkquelle and the Badequelle, which contain, according to Messrs Schnell and Stenner, in sixteen ounces:—

1. *Solids.*

	Haupttrinkquelle.		Badequelle.	
Carbonate of protoxide of iron	0.1152	grains	0	grains
carbonate of soda . .	5.9750	„	1.4131	„
carbonate of lime . .	11.5738	„	5.8675	„
carbonate of magnesia	5.4298	„	2.6880	„
chloride of potassium	0.1920	„	0.0767	„
chloride of sodium . .	0.6067	„	0.1229	„
alumina	0.0384	„	0.0768	„
silica	0.5837	„	0	„
	24.5146	grains.	10.8057	grains.

2. *Gases.*

Carbonic acid	28.6321	c. inch.	8.5939	c. inch.

The temperature of the two springs is 48°.6. They are efficacious in bronchial catarrh with atony of the mucous membrane, and disturbances of abdominal circulation.

XII. SULPHUROUS WATERS.

The therapeutical effects of the sulphurous Spas are due to the sulphur, the water, its temperature and the salines contained in it. They are extensively used

in diseases of the skin, and prove particularly beneficial not only in cases of acne, but also in the milder forms of pityriasis, psoriasis, prurigo, and sycosis. In a variety of cases where exudations are to be absorbed, as in swellings of the joints, in caries and necrosis, in old gunshot-wounds, and in gout and rheumatism, they are used with advantage, provided all inflammatory symptoms have subsided. In ozaena, clergymen's sore-throat, chronic catarrh of the larynx and the bronchial tubes, they frequently afford relief. In chronic poisoning by mercury, lead, and copper, they favour the elimination of the poison, and promote recovery. They have been much praised as remedies for abdominal plethora, and more especially for haemorrhoids; it seems, however, that they only do good in such cases if, besides the sulphur, a certain amount of salines is contained in them, or if baths of a high temperature are given. Finally, they may serve as means of diagnosis in cases of secondary syphilis. Under their use, syphilitic affections of the most various kind are very much aggravated; and if no visible symptoms of the distemper exist, but this is latent in the blood, it frequently manifests itself by specific affections of the mucous membranes and other parts, after the sulphurous Spas have been used for a week or a fortnight. Observations of this kind have been chiefly made by Drs Wetzlar and Reumont, of Aix-la-Chapelle. The sulphurous waters are employed externally and internally, and mineral mud-baths form a valuable auxiliary to this treatment.

The most important sulphurous thermals are those of Aix-la-Chapelle, the chemical composition of which is, according to Baron Liebig, as follows:—

1. *Solids.*

	Kaiserquelle. 131°.	Corneliusquelle. 113°.6.
Chloride of sodium . .	20.271 grains	18.934 grains
bromide of sodium . .	0.028 „	0.028 „
iodide of sodium . . .	0.004 „	0.004 „
sulphuret of sodium . .	0.073 „	0.042 „
carbonate of soda . . .	4.995 „	3.817 „
sulphate of soda . . .	2.171 „	2.201 „
sulphate of potash . . .	1.186 „	1.204 „
carbonate of lime . . .	1.217 „	1.012 „
carbonate of magnesia .	0.395 „	0.192 „
carbonate of strontia .	0.002 „	0.002 „
carbonate of lithia . . .	0.002 „	0.002 „
carbonate of protoxide of iron	0.073 „	0.046 „
silica	0.508 „	0.459 „
organic matter	0.577 „	0.713 „
	31.502 grains.	28.654 grains.

2. *Gases.*

The gases which are contained in the same springs, consist of:—

Nitrogen	9 per cent	7.79 per cent
carbonic acid	89.40 „	92.91 „
carburetted hydrogen .	0.37 „	traces
oxygen	1.23 „	traces

The gases which ascend from the water, consist of:—

	Kaiserquelle.	Corneliusquelle.
Nitrogen	66.98 per cent	81.68 per cent
carbonic acid	30.89 „	17.60 „
carburetted hydrogen .	1.82 „	0.72 „
sulphuretted hydrogen	0.31 „	0.00 „

The Rosenquelle and Quirinusquelle, of Aix-la-Chapelle, contain, according to Liebig, in sixteen ounces of water:—

1. *Solids.*

	Rosenquelle. 116°.6.	Quirinusquelle. 121°.3.
Chloride of sodium . .	19.552 grains	19.937 grains
bromide of sodium . .	0.028 „	0.028 „
iodide of sodium . . .	0.004 „	0.004 „
sulphuret of sodium . .	0.057 „	0.018 „
carbonate of soda . . .	4.065 „	4.244 „
sulphate of soda . . .	2.176 „	2.243 „
sulphate of potash . . .	1.183 „	1.164 „
carbonate of lime . . .	1.413 „	1.330 „
carbonate of magnesia .	0.204 „	0.257 „
carbonate of strontia .	0.002 „	0.002 „
carbonate of lithia . . .	0.002 „	0.002 „
carbonate of protoxide of iron	0.046 „	0.040 „
silica	0.455 „	0.476 „
organic matter	0.703 „	0.751 „
	29.888 grains.	30.496 grains.

2. *Gases.*

The gases contained in the water, consist of:—

	Rosenquelle.	Quirinusquelle.
Nitrogen	9.14 per cent	6.41 per cent
carbonic acid	90.31 „	93.25 „
carburetted hydrogen .	0.55 „	0.26 „
oxygen	0 „	0.08 „

The therapeutical effects of Aix-la-Chapelle are due to the water, its high temperature, and the sulphur and the chloride of sodium contained in it. It is an excellent remedy for all complaints which are generally benefitted by sulphurous waters; moreover, it appears from the observations of Dr Wetzlar, that patients suffering from progressive muscular atrophy and scrofula may, under certain circumstances, be improved or cured by its use.

The springs of Borcette which adjoins Aix-la-Chapelle, are very similar to those of the latter place. The following is the most recent analysis which has been made of one of these waters by M. Wildenstein:—

1. *Solids.*

Sulphate of potash	1.296 grains
sulphate of soda	2.366 „
chloride of sodium	21.788 „
iodide of sodium	0.001 „
bromide of sodium	0.012 „
sulphuret of sodium	0.0005 „
carbonate of soda	4.589 „
carbonate of lithia	0.073 „
carbonate of magnesia	0.209 „

carbonate of lime	1.425 grains
carbonate of strontia	0.003 ,,
carbonate of protoxide of iron . . .	0.002 ,,
carbonate of protoxide of manganese	0.001 ,,
carbonate of copper	0.0007 ,,
phosphate of alumina	0.0007 ,,
phosphate of lime	0.002 ,,
arseniate of lime	0.0002 ,,
silica	0.568 ,,
organic matter	0.019 ,,
	33.337 grains.

2. *Gases.*

Carbonate of ammonia	0.060 cub. inches
carbonic acid, half-bound . .	2.715 ,, ,,
free carbonic acid	0.081 ,, ,,
	2.856 cub. inches,

and traces of sulphate of rubidia, sulphate of caesia, borate of soda, nitrate of soda, carbonate of baryta and fluoride of calcium. Borcette is suitable for the same cases in which Aix-la-Chapelle proves beneficial.

The waters of Baden, near Vienna, are mostly used for bathing, and mineralised mud is employed for baths and cataplasms. The temperature of the waters varies, in the several baths, from 89°.4 to 95°.2, and the chemical composition of the two principal springs of the place is, according to Keller, as follows:—

1. *Solids.*

	Römerquelle. 94°.07.	Leopoldsquelle. 91°.7.
Sulphuret of magnesium	0.125 grains	0.118 grains
sulphate of lime	5.6563 „	5.5473 „
sulphate of potash . . .	0.4892 „	0.5560 „
sulphate of soda	2.1281 „	2.5766 „
chloride of sodium . . .	1.9906 „	2.2659 „
carbonate of lime . . .	1.3056 „	1.5936 „
carbonate of soda . . .	0.5329 „	0.0530 „
chloride of magnesium .	1.6156 „	1.5145 „
silica	0.1850 „	0.2166 „
organic matter	0.0431 „	0 „
	14.0696 grs.	14.4519 grs.

2. *Gases.*

Carbonic acid	1.433 c. inch.	3.2256 c. inch.
sulphuretted hydrogen	0.082 „	0.6720 „
nitrogen	0.465 „	7.8711 „
oxygen	0.052 „	0.9033 „
	2.032 c. inch.	12.6780 c. inch.

The waters of Baden are, in consequence of their somewhat lower temperature, inferior to those of Aix-la-Chapelle, for rheumatism and rheumatic paralysis; but as the air in Baden is much more bracing than in Aix-la-Chapelle, the former Spa is more appropriate for catarrh and scrofula.

Amongst the sulphurous thermals of Hungary, the springs of Mehadia, or Hercules' baths, are those most largely used. They have, according to D^r Ragsky, the following chemical composition:—

1. *Solids.*

	Kaiserquelle. 131°—133°.	Ferdinandsquelle. 129°.
Chloride of sodium . .	31.111 grains	25.348 grains
chloride of calcium . .	16.134 ,,	16.634 ,,
sulphate of lime . . .	0.334 ,,	0.480 ,,
carbonate of lime . . .	0.562 ,,	0.544 ,,
silica	0.165 ,,	0.204 ,,
iodide and bromide of calcium	traces	traces
	48.306 grains.	42.610 grains.

2. *Gases.*

Sulphuretted hydrogen	0.88 c. inch.	0.95 c. inch.
carbonic acid	0.62 ,,	0.72 ,,
nitrogen	0.58 ,,	0.40 ,,
carburetted hydrogen .	0.49 ,,	0.52 ,,
	2.57 c. inch.	2.59 c. inch.

1. *Solids.*

	Ludwigsquelle. 122°—124°.	Karlsbrunn. 116°.2—120°7.
Chloride of sodium . .	9.916 grains	7.187 grains
chloride of calcium . .	5.213 ,,	3.560 ,,
sulphate of lime . . .	0.782 ,,	0.594 ,,
carbonate of lime . . .	0.104 ,,	0.341 ,,
silica	0.112 ,,	0.145 ,,
iodide and bromide of calcium	traces	traces
	16.127 grains.	11.827 grains.

2. *Gases.*

	Ludwigsquelle.	Karlsbrunn.
Sulphuretted hydrogen	0.48 c. inch.	traces
carbonic acid	0.60 „	0.48 c. inch.
nitrogen	0.59 „	0.59 „
carburetted hydrogen .	0.41 „	0 „

The Hercules-spring communicates with rivulets and is therefore subject to great changes, both in its chemical composition and its temperature; the latter varies between 70° and 144°. Dr Ragsky's analysis, which was made after the weather had for a long time been dry and serene, is as follows:—

1. *Solids.*

Chloride of sodium	10.779 grains
chloride of calcium	7.800 „
sulphate of lime	0.605 „
carbonate of lime	0.364 „
silica	0.142 „
iodide and bromide of calcium	traces
	19.730 grains.

2. *Gases.*

Carbonic acid	0.56 cub. inches
nitrogen	0.50 „ „
	1.06 cub. inches.

The chemical composition of these springs therefore resembles that of the Aix-la-Chapelle waters, while the scenery of Mehadia is greatly superior to that of the latter place. The waters are much used in severe

forms of rheumatism and gout, old gunshot-wounds, and scrofula. This Spa is visited principally by the officers and soldiers of the Austrian army.

The thermals of Baden, in Switzerland, contain, according to Löwig, in sixteen ounces of water:—

1. *Solids.*

Chloride of sodium . .	13.042	grains
sulphate of lime	10.860	,,
carbonate of lime . . .	2.599	,,
sulphate of magnesia . .	2.442	,,
sulphate of soda	2.218	,,
chloride of potassium .	0.711	,,
chloride of calcium . .	0.719	,,
chloride of magnesium .	0.566	,,
fluoride of calcium . . .	0.016	,,
phosphate of alumina .	0.006	,,
carbonate of magnesia .	0.152	,,
carbonate of strontia . .	0.005	,,
silica	0.007	,,
bromides and iodides . .	traces	
	33.343	grains.

2. *Gases.*

Carbonic acid	22.80	cub. inches
nitrogen	125.26	,, ,,
oxygen	5.91	,, ,,

The amount of sulphuretted hydrogen contained in this water is so small that it was found impossible to determine it, although its presence is rendered certain by its peculiar odour. The thermals of Baden are

useful in most diseases in which the other sulphurous waters are employed, and more especially in certain forms of gout and rheumatism. The temperature of the several springs ranges between 117° and 122°.

The Euganean thermal springs, which rise in large numbers from the trachyte of the Euganean mountains, in Venetia, are almost exclusively employed for bathing. The waters of Abano, which are the most important amongst them, contain, according to a somewhat questionable analysis by Signor Ragazzini, in a thousand grammes:—

1. *Solids.*

Chloride of sodium . .	3.871	grammes
chloride of calcium . .	0.097	,,
chloride of magnesium	0.131	,,
sulphate of lime . . .	1.152	,,
iodide of magnesium .	0.022	,,
bromide of magnesium	0.010	,,
carbonate of lime . .	0.401	,,
carbonate of magnesia	0.098	,,
silica	0.372	,,
organic matter and silicate of iron	0.428	,,
	6.582	grammes

or 50.758 grains in sixteen ounces.

2. *Gases.*

The gases ascending from the springs consist of

carbonic acid . . . . . 38.0 cubic centim.

nitrogen	60.9	cubic centim.
sulphuretted hydrogen .	0.5	„ „
naphtha	0.5	„ „
oxygen	0.1	„ „
	100.0	cubic centim.

The baths of Abano are much prescribed in cases of gout, rheumatism, and scrofula, in which exudations are to be absorbed. The mineralised mud ("fango naturale") of the same place is a potent auxiliary to the treatment.

Amongst the sulphurous thermals of France, those of Aix-les-Bains, or Aix-in-Savoy, are the most important. They have, according to Bonjean, the following chemical composition:—

1. *Solids.*

	Sulphur-spring. 108°.25—111°.	Alum-spring. 108°.25—116°.34.
Sulphate of soda . . .	0.7374 grains	0.3256 grains
sulphate of magnesia .	0.2709 „	0.2380 „
sulphate of lime . . .	0.1229 „	0.1152 „
sulphate of alumina . .	0.4209 „	0.4761 „
sulphate of iron	traces	traces
chloride of sodium . .	0.0613 „	0.1075 „
chloride of magnesium .	0.1322 „	0.1690 „
fluoride of calcium, phosphate of lime and alumina	0.0191 „	0.0200 „
iodide of potassium . .	traces	traces

	Sulphur-spring. 108°.25—111°.	Alum-spring. 108°.25—116°.34.
carbonate of lime . . .	1.1405 grains	1.3901 grains
carbonate of strontia .	traces	traces
carbonate of protoxide of iron	0.0680 „	0.0719 „
silica	0.0384 „	0.0330 „
	3.3023 grains.	3.1541 grains.
2. *Gases.*		
Nitrogen	0.03204 vols.	0.08010 vols.
carbonic acid	0.02578 „	0.01334 „
sulphuretted hydrogen.	0.04140 „	0 „
oxygen	0 „	0.01840 „
	0.09922 vols.	0.11184 vols.

I have already mentioned the douche at Aix-les-Bains as being an excellent remedial agent. It proves chiefly useful in rheumatism, sciatica, and gout, even if the cases are of long standing and of a severe character.

The Pyrenees are very rich in sulphurous thermals. Those best known are Barèges, Bagnères de Luchon, St. Sauveur, Cauterets, Eaux-Bonnes, Eaux-Chaudes, Ax Vernet, and Amélie-les-Bains.

At Barèges, eight different springs are used for medical purposes, which have the following temperature:—

La Chapelle	87°.8.
Genecy	89°.6.
Dassieu	95°.

Le Fond	96°.8.
Bain Neuf	98°.6.
Polard	100°.4.
L'Entrée	104°.
Le Tambour or la Douche . .	113°.

Le Tambour contains, according to M. Longchamp, in sixteen ounces:—

1. *Solids.*

Sulphuret of sodium . .	0.360 grains
sulphate of soda	0.384 „
chloride of sodium . . .	0.307 „
silica	0 519 „
lime (?)	0.022 „
magnesia (?)	0.026 „
soda (?)	0.039 „
	1.657 grains.

2. *Gases.*

Nitrogen	0.004 cub. inch.

The waters of Barèges, more particularly those of a high temperature, are very exciting. They augment all secretions and, if incautiously taken, produce febrile symptoms, and in persons disposed to congestion, they may even cause apoplexy. The baths are mostly employed in old gunshot-wounds, atonic ulcers, muscular and tendinous contractions, stiffness of the joints and engorgements consequent upon fractures and dislocations. Rheumatism of the joints is however not benefitted by them, and if they are used in gout, the par-

oxysms of this disease become more frequent and severe. Patients suffering from pulmonary affections generally feel an increase of suffering, and should therefore avoid these waters. Dr James calls Barèges the "Siberia of France", where icy cold rapidly succeeds tropical heat.

The waters of Bagnères de Luchon greatly resemble those of Barèges in their chemical composition; they contain only 2.058 grains of solid ingredients in the pound, the most important amongst which is sulphuret of sodium. The establishments at this Spa are far superior to those of Barèges, and beneficial results are obtained by the use of the waters in most complaints in which Aix-la-Chapelle proves curative.

The waters of Saint-Sauveur have a sedative effect and are chiefly used in diseases of the nervous system accompanied by great irritability. The chemical composition of these springs being very similar to that of the Barèges waters, this soothing action can only be due to their lower temperature, which is 94°.

The waters of Eaux-Chaudes are valuable in muscular rheumatism with great irritability of the nervous system, and in certain diseases of women, such as neuralgic dysmenorrhoea.

The springs of Cauterets which contain less sulphur than most other sulphurous thermals of the Pyrenees, are employed in catarrh of the respiratory organs, and chronic metritis.

The waters of Eaux-Bonnes contain no sulphuret

of sodium or calcium, but sulphuretted hydrogen. They are often recommended in diseases of the chest, but it is doubtful whether they really do much good in such cases.

Amongst the cold sulphurous springs, those of Nenndorf, in Electoral Hesse, are of great importance. They contain, according to Professor Bunsen:—

1. *Solids.*

	Trinkquelle.	Badequelle.
Sulphate of lime . . .	8.121 grains	5.461 grains
carbonate of lime . .	3.381 ,,	3.541 ,,
sulphate of magnesia .	2.318 ,,	1.812 ,,
sulphate of soda . . .	4.549 ,,	1.995 ,,
sulphate of potash . .	0.339 ,,	0.135 ,,
chloride of magnesium	1.851 ,,	0.515 ,,
silica	0.162 ,,	0.091 ,,
hydrated sulphuret of calcium	0.555 ,,	0.134 ,,
	21.276 grains.	13.685 grains.

2. *Gases.*

	cub. centimètres.	cub. centimètres.
Sulphuretted hydrogen .	21.156	9.900
carbonic acid	86.517	146.783
nitrogen	10.151	32.450
carburetted hydrogen . .	0.857	0.230
	118.681	189.363

Inhalations of sulphuretted hydrogen, and mineral mud-baths are extensively used at this Spa, which is

chiefly resorted to by patients suffering from gout and rheumatism, certain forms of paralysis and neuralgia, and diseases of the skin. There is also a brine-spring at Nenndorf which is much employed for baths.

The springs of Eilsen, in the Principality of Schaumburg-Lippe, contain, according to Dumesnil, in sixteen ounces:—

1. *Solids.*

	Georgenbrunnen.	Julianenquelle.
Sulphate of soda . . .	5.8233 grains	5.0873 grains
sulphate of lime . . .	15.2840 „	17.1933 „
sulphate of magnesia .	5.0120 „	4.4933 „
carbonate of lime. . .	2.3333 „	1.5413 „
carbonate of magnesia	0.1620 „	0.1866 „
chloride of magnesium	1.2940 „	2.0500 „
phosphate of lime . .	0.0067 „	0.0080 „
peroxide of iron (?) . .	0.0066 „	0.0080 „
silica	traces	0.0746 „
	30.0051 grains.	30.6424 grains.

2. *Gases.*

Sulphuretted hydrogen	1.5740 c. inch.	2.096 c. inch.
carbonic acid	1.4480 „	2.151 „
nitrogen	0.3166 „	0.374 „
carburetted hydrogen .	0.0833 „	0.110 „
oxygen	0.0786 „	0.080 „
	3.5005 c. inch.	4.811 c. inch.

The mineral mud of this place has, according to Dumesnil, the following composition:—

1. *Solids.*

Humid acid	298.910	grains
vegetable fibres . . .	200.590	,,
wax-resin	6.060	,,
earth-resin	4.308	,,
sulphur	29.578	,,
sulphate of lime . . .	52.540	,,
carbonate of lime . .	40.420	,,
	623.406	,,
water	7031.194	,,
loss	16.400	,,
	7680.000	grains.

2. *Gases.*

Sulphuretted hydrogen . 0.22 c. inch.

The baths of Eilsen are suitable for the same diseases in which Nenndorf proves useful.

The sulphurous spring of Meinberg, in the Principality of Lippe-Detmold, contains, according to Brandes, in sixteen ounces:—

1. *Solids.*

Sulphate of soda	5.8444	grains
sulphate of magnesia	1.7333	,,
sulphate of potash	0.0057	,,
sulphuret of sodium	0,0677	,,
sulphate of lime	8.3353	,,
sulphate of strontia	0.0080	,,
chloride of magnesium	1.0353	,,
carbonate of lime	2.1494	,,

carbonate of magnesia	0.1723	grains
carbonate of protoxide of iron	0.0080	,,
phosphate of alumina	0.0100	,,
silica	0.1200	,,
	19.4894	grains.

2. *Gases.*

In 100 cubic inches of water:—

Sulphuretted hydrogen . . .	2.13	c. inch.
carbonic acid	8.11	,,
nitrogen	1.41	,,
oxygen	0.08	,,
	11.73	c. inch.

The sulphurous mud of Meinberg consists of

Sulphuret of sodium	15.582	grains
chloride of magnesium	7.476	,,
chloride of sodium	5.044	,,
sulphate of potash	2.156	,,
sulphate of soda	22.016	,,
sulphate of lime	77.224	,,
carbonate of lime	307.912	,,
carbonate of magnesia	4.800	,,
silica	1282.000	,,
alumina	216.000	,,
peroxide of iron	111.000	,,
peroxide of manganese	0.800	,,
phosphate of lime	1.000	,,
green resin	14.000	,,
yellow resin	4.000	,,

wax	2.000	grains
soluble nitrogenous organic matter .	4.000	,,
gummous extractive matter	10.000	,,
humic acid	42.000	,,
matter extracted by caustic potash .	28.000	,,
nitrogenous matter extracted by caustic potash	968.000	,,
vegetable fibre	4473.890	,,
sulphuretted hydrogen	indefinite	
	7680.000	grains.

There are also acidulous and muriated waters at Meinberg, which Spa has not yet been so extensively used as its many curative resources seem to warrant. It is chiefly visited by patients suffering from gout and rheumatism, scrofula, irregular menstruation, and certain forms of paralysis.

The sulphurous waters of Harrowgate have been analysed by D[r] Hofmann. They contain in sixteen ounces:—

1. *Solids.*

	Old sulphur well.		Montpellier strong.	
Sulphuret of sodium .	1.548	grains	1.441	grains
sulphate of lime . . .	0.013	,,	0.059	,,
carbonate of lime . . .	1.237	,,	2.418	,,
fluoride of calcium . .	trace		trace	
chloride of calcium . .	8.174	,,	6.191	,,
chloride of magnesium	5.569	,,	5.467	,,
chloride of potassium .	6.470	,,	0.575	,,

	Old sulphur well.	Montpellier strong.
chloride of sodium . .	86.018 grains	80.309 grains
bromide of sodium . .	trace	0 ,,
iodide of sodium . . .	trace	0 ,,
ammonia	trace	trace
carbonate of protoxide of iron	trace	0 ,,
carbonate of protoxide of manganese . . .	trace	0 ,,
silica	0.025 ,,	0.184 ,,
organic matter . . .	0	trace
	109.658 grains.	96.646 grains.
2. *Gases.*		
Carbonic acid	2.200 c. inch.	1.401 c. inch.
carburetted hydrogen.	0.584 ,,	0.053 ,,
sulphuretted hydrogen	0.531 ,,	0 ,,
oxygen	0 ,,	0.048 ,,
nitrogen	0.291 ,,	0.482 ,,
	3.409 c. inch.	1.984 c. inch.

These waters are distinguished by the large amount of sulphuret and chloride of sodium they contain, and are suitable for all cases in which other muriated and sulphurous springs are employed.

The sulphurous spring of Weilbach is used with advantage in cases of chronic catarrh of the stomach and intestines, bronchitis, and catarrh of the bladder; it contains, according to Fresenius, in sixteen ounces:—

1. *Solids.*

Bicarbonate of soda	3.123	grains
bicarbonate of lithia	0.006	„
bicarbonate of baryta . . .	0.009	„
bicarbonate of strontia . . .	0.001	„
chloride of sodium	2.083	„
chloride of potassium . . .	0.214	„
sulphate of potash	0.298	„
phosphate of alumina . . .	0.001	„
phosphate of lime	0.002	„
carbonate of lime	2.909	„
carbonate of magnesia . . .	2.758	„
silica	0.111	„
organic matter	0.037	„
	11.566	grains.

2. *Gases.*

Sulphuretted hydrogen . .	0.1669	cubic	inches.
carbonic acid	3.126	„	„

This water is a weak acidulous alkaline and therefore more easily digestible than that of Nenndorf and Eilsen. It generally increases the appetite and promotes digestion.

In conclusion, I will mention the sulphurous baths of Sandefjord, on the southern coast of Norway, which may be used in most cases in which cold sulphurous Spas are suitable. Sixteen ounces of this water contain, according to Professor Strecker:—

1. *Solids.*

Chloride of sodium . .	129.697	grains
chloride of magnesium .	17.010	,,
bromide of magnesium .	0.491	,,
sulphate of potash . . .	4.056	,,
sulphate of lime	4.471	,,
carbonate of magnesia .	5.223	,,
carbonate of lime . . .	4.182	,,
carbonate of iron . . .	0.358	,,
carbonate of manganese	0.062	,,
alumina	0.052	,,
silica	0.210	,,
organic matter	1.744	,,
	167.556	grains.

2. *Gases.*

Carbonic acid	4.861	grains
sulphuretted hydrogen .	0.135	,,

and traces of ammonia, nitric acid, and boracic acid. The quantity of chlorides contained in this water being very considerable, it should be diluted with fresh water before being drunk. Sea-baths and mud-baths are also given at Sandefjord. The custom which still prevails there of using the jelly-fish (Medusa capillata Linn.) for producing irritation of the skin, is injudicious, and we should strongly recommend the Physicians of that Spa to discontinue this proceeding altogether.

THE END.

BIBLIOGRAPHY.

Henri de Rochas, Traité des observations nouvelles et vraie connaissance des eaux minérales. Paris 1634.

Duclos, Observations sur les eaux minérales des plusieurs provinces de France faites en l'Académie Royale des sciences. Paris 1675.

R. Plot, De origine fontium tentamen philosophicum. Oxonii 1685.

R. Boyle, Historia naturalis aquarum mineralium. London 1686.

F. Hofmann, Methodus examinandi aquas salubres. Halae 1703. — Dissertatio de acidularum et thermarum virtute. 1712. — De balneorum artificialium ex scoriis metallorum usu medico. 1722. — Scrutinium principiorum et virtutum in praecipuis medicatis Germaniae fontibus. 1729.

J. G. Stahl, Untersuchung der übel curirten Krankheiten. Leipzig 1726.

Th. Short, The natural, experimental and medical history of the mineral waters. London 1734.

Stiebritz, Ob der Teich Bethesda mit den warmen Bädern etc. Halle 1739.

J. G. Wallerius, Hydrologia. Stockholm 1750.

Le Monnier, Traité abrégé des eaux minérales de France. Lyon 1753.

Rutty, A methodical synopsis of mineral waters. London 1757.

W. Linden, On the origin, nature and virtues of mineral waters. London 1757.

Gomez de Bedoya, Historia universal de las Fuentes minerales del Espagna. S. Jago 1764.

Targioni Tozzetti, Relazioni d'alcuni viaggi fatli in Toscana. 6 vols. Florence 1768—79.

Monro, A treatise on mineral waters. London 1770.

Raulin, Traité analytique des eaux minérales en général. Paris 1772.

T. Bergmann, Svenska Veterscapets Academiens Handlingar. Upsala 1775. — De analysi aquarum. Upsala 1778.

Duchanoy, Essai d'imiter les eaux minérales. Paris 1780.

Gottling, Almanach für Scheidekunst. 1780.

Langier, Minéralogie nouvelle. Sans 1786.

Swinbourne, Travels in the two Sicilies in the years 1777—80. London 1785—90.

Elliott, An account of the nature and medical virtues of the principal mineral waters of Great Britain and Ireland. London 1789.

Kirwan, An essay on the Analysis of mineral waters. London 1799.

Saunders, A Treatise on the chemical history and medical powers of some of the most celebrated mineral waters. London 1805.

Wetzler, Ueber Gesundbrunnen und Bäder. 3 volumes. Mainz 1819—25.

Hufeland, Praktische Uebersicht der vorzüglichsten Heilquellen Deutschlands. Berlin 1820.

Bertini, Idrologia minerale ossia storia de tutte le sorgenti d'acque minerale negli stati di Sardegna. Torino 1822.

Alibert, Précis historique sur les eaux minérales les plus usitées en médecine. Paris 1824.

Bischof, Die vulkanischen Mineralquellen Deutschlands. Bonn 1826. — Die Wärmelehre des Inneren unsers Erdkörpers. Leipzig 1837.

Pietro Paganini, Notizia compendiata di tutte le acque minerali e bagni d'Italia. Milano 1827.

Salvatore de Renzi, Osservazione sulla topografia medica del regno di Napoli. 3 vols. Napoli 1828—30.

Osann, Physikalisch-medizinische Darstellung der bekannten Heilquellen der vorzüglichsten Länder Europas. Berlin 1829—32. 2d edition 1839.

Giuseppe Giulii, Storia naturale di tutte le acque minerali di Toscana. 6 volumes. Florence and Siena 1833—36.

Granville, The Spas of Germany. London 1837. — The Spas of England and principal sea-bathing places. London 1841.

Vetter, Theoretisch-praktisches Handbuch der Heilquellenlehre. Berlin 1838. — 2d edition 1845.

Simon, Die Heilquellen Europas. Berlin 1839.

Landerer, *περὶ τῶν τῆς Ἑλλαδος ἰαματικῶν ὑδατῶν.* Athens 1840.

von Graefe, Die Gasquellen Süd-Italiens und Deutschlands. Berlin 1842.

Knox, On Irish watering places. Dublin 1845.

Harless, Die sämmtlichen bisher in Gebrauch gekommenen Heilquellen und Kurbäder etc. Vol. I. Berlin 1846.

Lee, The baths of Germany. London 1846. — The baths and watering places of England. London 1848.—The baths of France, Central Germany and Switzerland. London 1854.

Harless, Die Heilquellen und Kurbäder Italiens. Berlin 1848.

Sutro, Lectures on the German mineral waters. London 1852.

Constantin James, Guide pratique aux eaux minérales. Paris 1852.

Posner, Encyklopädisches Handbuch der Brunnen- und Bäderkunde. Berlin 1853.

Helfft, Handbuch der Balneotherapie. Berlin 1854. — 4th edition 1859.

Lersch, Einleitung in die Mineralquellenlehre. Vol. I. Erlangen 1855. — Vol. II. 1860.

Herpin, Etudes médicales et statistiques sur les principales sources des eaux minérales etc. Paris 1856.

Constantin James, Guide pratique du médecin et du malade aux eaux principales de France etc. Paris 1856.

Glover, On mineral waters, their physical and medicinal properties. London 1857.

Durand-Fardel, Traité thérapeutique des eaux minérales de France et de l'étranger. Paris 1857.

Seegen, Compendium der allgemeinen und speziellen Heilquellenlehre. 2 vols. Vienna 1857—58. — 2d edition 1862.

Helfft, Balneo-Diätetik. Berlin 1858.

Sales-Girons, Thérapeutique respiratoire. Traité théorique et pratique etc. Paris 1858.

Meyer-Ahrens, Die Heilquellen und Kurorte der Schweiz. 2 vols. Zürich 1860.

Durand-Fardel, Eugène le Bret, et Jules Lefort, Dictionnaire général des eaux minérales et d'hydrologie médicale. Paris 1860.

Ditterich, Klinische Balneologie. München 1861.

Ewich, Praktisches Handbuch über die vorzüglichsten Heilquellen und Kurorte. Berlin 1862.

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